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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

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Biological Sciences

BIRD POPULATIONS IN FIVE MAJOR WEST-CENTRAL FLORIDA VEGETATION TYPES

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ABSTRACT: *Density estimates are presented for 77 bird species observed in 5 major vegetation types in west-central Florida. Sixty-four transects and plots were sampled seasonally in 1976. Species richness was greatest in the woodland type and least in the cropland; 2 pasture types and a meadow type were intermediate. Bird densities also were greatest in the woodland type followed by the meadow. Species frequenting aquatic habitats were important in the seasonally wet meadow type. Various habitat features and land management practices, which greatly influence bird populations, are discussed.*

HABITAT SELECTION by bird species is most strongly influenced by the structure of the vegetation. Birds are sensitive indicators of habitat conditions, because each species has its own distinctive habitat requirements. Little study has been conducted on avian populations in vegetation types in central Florida (Hirth and Marion, 1979). Land management practices in this region exert a profound influence on all bird species, and as these practices continue to change, bird populations will respond and reflect vegetational changes. This study was part of an environmental assessment project to investigate plant and animal populations in several habitats on a large study area in west-central Florida (Texas Instruments, 1978). The seasonal composition of the bird community in 5 major vegetation types is described in this paper.

STUDY AREA—The study area encompassed 8,134 ha in north-central DeSoto County, 16 km northeast of Arcadia. The site was predominantly native range; land uses included cattle ranching and a relatively small amount of improved pasture and cucurbit fields.

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The site lies at the biogeographic boundary between temperate and subtropical climates. Mean monthly temperatures in the site vicinity range from 17°C in January to 28°C in August. Annual rainfall averages 137 cm and shows a marked seasonality of only 5 cm in November to 22 cm in July. General weather conditions during the 1976 study period were slightly cooler temperatures and considerably drier than normal.

The site is drained to the north by Fish Branch and to the west by Sand Gully, 2 intermittent streams, and to the south by Joshua Creek. The western portion of the site bordered the Peace River. Numerous, shallow, closed depressions occur over the site. Other water bodies include irrigation and drainage ditches, stock ponds, and borrow pits. Open water occupied less than 5 ha in May. Soils over most of the site are predominantly thick acid sands with poorly-drained organic pans.

HABITAT DESCRIPTION—Unimproved pasture was the most common vegetation cover type, extending over approximately 70% of the total site area. Characteristic vegetation included saw palmetto *(Serenoa repens)*, pineland threeawn *(Aristida tenuispica)*, and scattered individuals or small strands of longleaf pine *(Pinus palustris)*. Saw palmetto, because of frequent burning, was usually less than 1 m tall. Pineland threeawn, a perennial bunchgrass in the wiregrass group, supported much of the cattle grazing on the site. Other important grasses in the unimproved pasture included rattail smutgrass *(Sporobolus poiretii)* and West Indies smutgrass *(S. indicus)*. The most commonly occurring shrub was shiny blueberry *(Vaccinium myrsinites)*. A total of 120 plant taxa was observed in unimproved pastures during the study.

Meadows, representing 16% of the site area, characteristically occupied lower elevations within the unimproved pasture. While some of the meadows were modified by water management techniques, most were unmodified and supported typical wet prairie vegetation. Prevalent plant species were maidencane *(Panicum hemitomon)*, yellow-eyed grass *(Xyris)*, and pickerelweed *(Pontederia cordata)*. The most common shrub was button-bush *(Cephalanthus occidentalis)*. Of the 128 plant taxa observed in the meadow type, many are characteristic of wet habitats, and several are restricted to aquatic habitat.

Approximately 7% of the site area in 1976 was cropland. Crops under cultivation were watermelon *(Citrullus vulgaris)* and cucumber *(Cucumis sativus)*. After crop harvest, volunteer plants persisted until late summer when 2 forage crops, hairy indigo *(Indigofera hirsuta)* and shy-leaf *(Aeschynomene americana)*, were planted. Fringe rush *(Fimbristylis spadicea)*, a sedge species, was the most common noncrop species.

Improved pastures accounted for 6% of the site's vegetative cover. A few scattered shrubs, saplings, and trees were present in older pastures near the Peace River. Most pastures were younger, some being recently converted from cropland. Of the 101 plant taxa identified, about half were monocots. Carpet grass *(Axonopus affinis)* was the most abundant species. Rattail smutgrass and Bahia grass *(Paspalum notatum)* also were important grasses. Shy-leaf was the most important forb species.

Woodlands comprised less than 2% of the vegetative cover on the site with riparian hardwoods along the drainage courses accounting for most of the acreage. Although the amount of woodlands was small, the number of plant taxa (149) was greater than that for any other vegetation type. Laurel oak *(Quercus laurifolia)* was the most important tree species. Other important woody species were inkberry *(Ilex glabra)*, Carolina ash *(Fraxinus caroliniana)*, catbrier *(Smilax bona-nox)*, winged sumac *(Rhus copallina)*, and trumpet creeper *(Campsis radicans)*. Common herbaceous taxa were primarily grasses and sedges. A few small cypress and sweet bay stands also were present. Prevalent woody species in these stands were bald cypress *(Taxodium distichum)*, pond cypress *(T. ascendens)*, sweet bay *(Magnolia virginiana)*, and red maple *(Acer rubrum)*.

METHODOLOGY—Sixty-four sampling locations were established within the 5 vegetation types to ensure site coverage and to be representative of the various habitats and conditions within each type. Each location was sampled in each of the 4 seasons in 1976. A belt transect technique modified from Bond's (1957) sample-count method was used to census birds in all types except the woodland. Transects of 50-m width and varying lengths were walked, and all birds sighted within the transect limits were identified and counted.

In wooded locations, which included riparian, cypress, sweet bay, and oak stands, 10 circular plots were established and surveyed as described by Fowler and McGinnes (1973). All birds were identified and counted within a defined 30-m radius area. Data for each transect or plot during each of the 4 sampling periods were expanded to number of individuals per 40 ha for each vegetation type.

RESULTS AND DISCUSSION—Of the 131 bird species observed on the site in 1976, 77 were censused within transects or plots. The remaining 54 species were sighted either on roadside counts or were recorded as incidental observations.

Unimproved Pasture: A wide variety of palmetto habitats was represented among the unimproved pasture sampling locations. The amount and type of woody vegetation greatly influenced bird species diversity (richness) and abundance (density) within this habitat type. Overall bird densities for winter and summer were lower than those reported by Hirth and Marion (1979) in a pine flatwoods habitat in Manatee County. Species richness in the unimproved pasture was intermediate between that of the improved pasture and meadow types (Tables 1 and 2). The eastern meadowlark (*Sturnella magna*) was the most abundant species in the unimproved pasture in each season. Hirth and Marion (1979) found this species to be the most abundant breeding bird and the second most abundant in January.

Other common species censused in winter were the savannah sparrow

Table 1. Numbers of birds per 40 hectares in unimproved and improved pasture vegetation types.

	Improved Pasture				Unimproved Pasture			
	WIN	SPR	SUM	FAL	WIN	SPR	SUM	FAL
Cattle Egret		11	3				22	
White Ibis								34
Turkey Vulture		3		3			3	
Black Vulture		3	5	3		4	3	
Red-tailed Hawk						2		
Red-shouldered Hawk			2				2	
Marsh Hawk				3				3
Bobwhite		8	11		7	12	9	11
Killdeer		6	2	3		2		3
Mourning Dove		6	5			8	8	
Ground Dove		8	5	3		8	11	3
Burrowing Owl		3	2					
Common Nighthawk		3	2			8	6	
Common Flicker		3		3			1	3
Red-bellied Woodpecker							2	
Red-headed Woodpecker						2	1	3
Eastern Kingbird		6				2	2	
Tree Swallow	10							
Blue Jay						2	2	
Mockingbird	10	8	8	12	11	8	7	6
Brown Thrasher		3				2	3	3
American Robin	35				2			
Eastern Bluebird		3						
Loggerhead Shrike	3	6		3	4	4	7	8
White-eyed Vireo					2	2	3	3
Yellow-rumped Warbler					5			
Palm Warbler	3				4			3
Common Yellowthroat	3	3	2		13	10	9	3

Bobolink		55						
Eastern Meadowlark	21	33	35	36	22	51	42	48
Red-winged Blackbird		6	6	21		2	6	11
Boat-tailed Grackle		3	3	3		2	4	
Common Grackle							1	
Cardinal						2	1	3
Rufous-sided Towhee		7	2	6	5	8	8	25
Savannah Sparrow	7	3			22			
Bachman's Sparrow						12	12	8

TABLE 2. Numbers of birds per 40 hectares in meadow and cropland vegetation types.

	Meadow				Cropland			
	WIN	SPR	SUM	FAL	WIN	SPR	SUM	FAL
Anhinga				10				
Great Blue Heron	3	3	5	10				
Green Heron		16	50	15		8		
Little Blue Heron	22	3	14	49				
Cattle Egret	19		4					
Great Egret	57	29	18	19		8		
Snowy Egret	47	13	16	29				
Louisiana Heron	3	3	14	10				
Least Bittern	3		18					
American Bittern	13							
Wood Stork	79	58	5	19				
White Ibis		10	2	1746				
Mottled Duck		6	21	15		17		

Turkey Vulture								11
Marsh Hawk	3			10				5
Sandhill Crane			4					
King Rail		6	5					
Common Gallinule			5	19				
Killdeer	3			10	27		9	11
Common Snipe	41			29				
Greater Yellowlegs				5				
Lesser Yellowlegs				5				
Mourning Dove			2		21	27	27	
Ground Dove			2					
Common Nighthawk							9	
Eastern Kingbird		3	5					
Tree Swallow	41							
Mockingbird			5	5		9		
Palm Warbler	22				5			32
Common Yellowthroat	13	19	12	5				
Bobolink						9		
Eastern Meadowlark		6	11	19	16	36	13	
Red-winged Blackbird	144	147	121	146	11	9	27	43
Boat-tailed Grackle	16	35	20	39			9	13
Savannah Sparrow	9				16			
Swamp Sparrow	6	10						

(Passerculus sandwichensis), common yellowthroat *(Geothlypis trichas),* and mockingbird *(Mimus polyglottos).* Savannah sparrows were most common along grassy roadsides and in areas where grasses and other monocots were abundantly interspersed with low, sparse palmetto. Yellowthroats and mockingbirds were more common in denser palmetto growth with some woody vegetation intermixed. Yellowthroats frequented wetter areas more often than either the mockingbird or savannah sparrow.

Bobwhites *(Colinus virginianus),* common yellowthroats, and Bachman's sparrows *(Aimophila aestivalis)* were common in the unimproved pasture during spring. Bachman's sparrow was restricted to unimproved pasture on the site and was distributed throughout the type except in low, sparse palmetto habitats. Palmetto appears to be more important than trees (pine) to this sparrow (Howell, 1932).

Bachman's sparrow was still common in summer along with the cattle egret *(Bubulcus ibis)* and ground dove *(Columbina passerina).* The cattle egret, which first appeared in Florida in the 1940s, now nests in almost every state and in Canada. Its numbers have increased several thousandfold in Florida (Bock and Lepthien, 1976), perhaps because of the successful occupancy of a vacant artificial feeding niche created by the Florida cattle industry (Jenni, 1969). The species may have a disruptive influence on native wading birds, especially exerting competitive pressure for nesting space in rookeries (Crowder, 1974). Maximum flock size on the site was 200 individuals; numbers on the site at any one time ranged up to 2,000 individuals.

Abundant species observed in fall were white ibis *(Eudocimus albus),* rufous-sided towhee *(Pipilo erythrophthalmus),* bobwhite, and red-winged blackbird *(Agelaius phoeniceus).* The white ibis is the most abundant, colonial nesting, wading bird species in Florida. Shallow water is required for feeding, and, as with many wading bird species, nesting success depends on available feeding locations that provide suitable water-depth conditions and prey concentration (Kushlan, 1978).

Species censused only in unimproved pasture included the Bachman's sparrow, red-tailed hawk (*Buteo jamaicensis*), and red-headed woodpecker (*Melanerpes erythrocephalus*). The latter 2 species were sighted in lone pines in the palmetto habitat.

The bobwhite, although observed in every vegetation type, was most prominent in the unimproved pasture. The Florida bobwhite continues to be a prime upland game species in Florida, where the annual harvest during the 1970s ranged between 1.7 and 3.2 million birds (FGFWFC, 1975). Typical nest sites on the study site included small clumps of palmettos situated in slightly elevated areas burned the previous winter or spring (Beckwith, 1967). Population estimates for the unimproved pasture in 1976 indicated a bird per 3.2 to 5.6 ha. Hirth and Marion (1979) reported a bird per 0.8 to 1.8 ha for a flatwoods habitat. The estimated winter average for the state several years ago was a bird per 6 to 8 ha (Murray and Frye, 1957);

concentrated management of the bird since then probably has increased overall populations. Land management practices similar to those on the site support bobwhites as well as other birds that are attracted to burns because of increased availability of food (Stoddard, 1963; Edwards and Ellis, 1969). Many small burns are more important in bobwhite management than the extensive burns practiced on the study area (Frye, 1954).

Meadow: The degree of wetness was an extremely important factor influencing bird populations in the meadow type. Vegetation, which ranged from predominantly grasses and other monocots to large-leaved herbaceous species to shrubby vegetation, also was important. Definite zones of vegetation, a result of the degree of wetness, influenced bird distribution in several of the larger meadow areas. The influence of these various factors resulted in a more uneven or patchy distribution of birds in the meadow than in other vegetation types. Ecotonal areas were important, particularly the large amount of edge habitat between unimproved pastures and meadows. Because the wetness of the meadows often stopped the periodic fires that burned the unimproved pasture, palmetto growth bordering marsh areas was sometimes larger, more dense, and intermixed with woody shrubs. Wet prairie vegetation of the meadow type did burn occasionally, resulting in at least, temporary favorable effects on birdlife similar to those realized in the unimproved pasture (Vogl, 1973). Because of the patchy distribution and high degree of mobility of many of the aquatic bird species, population estimates for the meadow type are probably less accurate than for the pasture types. Species richness equalled that of the unimproved pasture.

The red-winged blackbird was to the meadow type what the eastern meadowlark was to the pasture types (Tables 1 and 2). Red-wing populations remained constant in the meadow type throughout 1976 and was the most common species every season except fall, when large flocks of white ibis fed on the site. The next most abundant passerine inhabiting the meadow type as a permanent resident was the boat-tailed grackle (*Quiscalus mexicanus*). Boat-tails typically inhabit open areas near water. Several nesting colonies were observed in shrubs and other coarse vegetation in or near the meadow type.

As a group, wading birds (herons, egrets, bitterns, storks, and ibis) were particularly conspicuous. The most common species during winter and spring censuses were the wood stork (*Mycteria americana*) and great egret (*Casmerodius albus*); during summer surveys, the green heron (*Butorides straitus*); and during fall, in addition to white ibis, the little blue heron (*Florida caerulea*).

Wading birds often were conspicuous in most shallow water areas on the site. The extent of shallow water areas, which are highly productive because of their periodic drying and flooding, is being diminished throughout Florida by filling, digging of drainage canals, irrigation, and other methods of artificial water control. Wading bird populations have diminished concomitantly so that less than 10% of the population in 1870 is present today in south Florida (Crowder, 1974; Robertson and Kushlan, 1974). Kushlan and White (1977) reported that their 1975 estimate for south Florida represents a 13% decrease since 1970. The wood stork, which requires a greater concentration of fish than other waders, has declined the most, and it is currently the most endangered wader in Florida (Ogden, 1978). Wood storks were seen in scattered locations over the site, where they utilized various wet areas when food concentrations became favorable.

The white ibis was particularly common in fall on the study site. Flocks moved from wet area to wet area over the entire site in search of suitable feeding locations. When a suitable location was found, flocks of several hundred birds gathered. Estimating the total population on the site at any one time was difficult because of their high mobility and the swift flight of large flocks from one region to another. On 1 October the site's white ibis population was estimated at between 3,000 and 4,000 birds. No white ibis breeding colonies or roosts occurred on the site although a few great blue herons (*Ardea herodias*), great egrets, green herons, and least bitterns (*Ixobrychus exilis*) did nest.

All of the 13 bird species censused only in the meadow type typically inhabit aquatic or wet habitats.

Cropland: The rapid and drastic changes in croplands through the sampling year influenced species distribution, richness, and abundance. Habitats sampled included bare ground, young and mature watermelon and cucumber, disked areas following crop harvest, and recently seeded (to grasses and/or legumes) areas. The fewest number of bird species was censused in the cropland type; no species was restricted to croplands.

The mourning dove (*Zenaida macroura*), a permanent resident as well as a migrant in the area, was the species most characteristic of the cropland type (Table 2). The eastern meadowlark and red-winged blackbird also were conspicuous species in the type throughout the year. The largest dove flocks were observed in late July and early August. Other common species were killdeer (*Charadrius vociferus*) in January and palm warbler (*Dendroica palmarum*) in October.

Several species typically inhabiting wet areas were observed in the cropland type. Croplands frequently were wet because all cropland areas were irrigated using open ditches arranged at frequent regular intervals over entire fields. Also, following heavy rainfall, flooding from meadows inundated adjacent croplands. These conditions created suitable habitat for some waders, the mottled or Florida duck (*Anus fulvigula*), and certain shorebirds. Wading birds may find wet agricultural lands more acceptable feeding areas at times than natural wetlands.

Improved Pasture: The dominant bird species in all improved pasture sampling locations were those that typically occur in open grassland habitats (Table 1). In locations where woody vegetation in the form of shrubs, saplings, and trees was present, bird species that typically use these strata were found in greater abundance. Similar habitat partitioning also was quite evident in the unimproved pasture, where vegetation within the sampling transects varied from low, sparse, recently burned saw palmetto to areas where woody vegetation was an integral feature along with large, dense saw palmetto.

Species composition was similar to that for the unimproved pasture. Species censused in the improved pasture but not in the unimproved were the burrowing owl (*Athene cunicularia*), tree swallow (*Iridoprocne bicolor*), eastern bluebird (*Sialia sialis*), and bobolink (*Dolichonyx oryzivorus*). Species richness and abundance were generally lower than that for the unimproved pasture. The most abundant species for each of the 4 seasons were American robin (*Turdus migratorius*) in winter, bobolink in spring, and eastern meadowlark in summer and fall.

Woodland: Woodland vegetation structure was shaped by the degree of wetness, fire that sometimes encroached, and cattle grazing, all of which made the habitat more open. The diversity of woodland habitats, which varied in vegetation composition, structure, size, and degree of outside influence, was important in determining species presence. Twenty-two species were censused only in woodlands (Table 3).

Bird density estimates appear appreciably greater for woodlands than for other vegetation types. Several factors probably contributed. First, forested acreage sampled was less than for other types, thus each sighting, when translated to an area estimate, contributes considerably more to the estimate. Secondly, a greater species richness was found, which partially can be accounted for by the structural complexity of vegetation, but also by the number of edge species represented. Lastly, a greater number of individuals was present for certain species.

The most characteristic species of the woodlands was the Carolina wren (*Thryothorus ludovicianus*). It was the most abundant species in spring and summer, second most abundant in fall, and third most abundant in winter (Table 3). Carolina wrens typically inhabit undergrowth-filled woods, shrubby areas, thickets, and brushy streamsides and lakesides. The only woodland location in which this species was not sighted was a small cypress stand where undergrowth was virtually nonexistent.

Two warblers, the yellow-rumped (*Dendroica coronata*) and palm, were the most abundant species in winter. These 2 species plus the common yellowthroat, which was the third most abundant species in the woodlands during spring, were the only warbler species, of the 18 seen on the site, that were observed in vegetation types other than woods.

The blue-gray gnatcatcher (*Polioptila caerulea*) was common in winter and was the most abundant species in woodlands in fall. Cardinals (*Cardinalis cardinalis*) were conspicuous in woodland areas throughout the year and particularly in spring. The cardinal and Carolina wren were the most common species in mixed oak and wet maple woods in nearby Pinellas County (Rohwer and Woolfenden, 1969).

Conclusions—Even after 75 or more years of amateur bird watching

TABLE 3. Numbers of birds per 40 hectares in the woodland vegetation type.

	WIN	SPR	SUM	FAL
Green Heron			7	
Little Blue Heron	14			14
Wood Stork		14	7	
Wood Duck			21	
Turkey Vulture		28	57	14
Black Vulture		14	57	14
Red-shouldered Hawk	57	28	21	28
Bobwhite				57
Mourning Dove		14	35	
Yellow-billed Cuckoo		14		
Screech Owl	14			
Barred Owl			7	
Chuck-will's-widow			7	
Common Nighthawk		14		
Common Flicker			7	14
Pileated Woodpecker		14	14	
Red-bellied Woodpecker	28	28	49	57
Eastern Kingbird			14	
Great Crested Flycatcher		28	21	
Eastern Phoebe	14			
Acadian Flycatcher			7	
Blue Jay	28	42	42	28
Tufted Titmouse		28	14	14
Carolina Wren	157	184	177	184
Mockingbird	14	14	7	14
Gray Catbird		14		14
Brown Thrasher		42	14	14
American Robin	57			
Blue-gray Gnatcatcher	142			198
White-eyed Vireo	42	57	64	42
Solitary Vireo	14			
Black-and-white Warbler	28			
Northern Parula		42		
Black-throated Blue Warbler		14		
Yellow-rumped Warbler	198			
Yellow-throated Warbler	57			28
Blackpoll Warbler		14		
Pine Warbler		28	21	14
Prairie Warbler			7	
Palm Warbler	170			
Common Yellowthroat		71	49	28
American Redstart				57
Red-winged Blackbird	42			
Boat-tailed Grackle	14		21	
Common Grackle			7	
Cardinal	85	113	21	85
Rufous-sided Towhee	42	57	21	28

and professional ornithological effort in Florida, few data are available on the relative or absolute abundance of most bird species in the various vegetation types in the state. Today, with the practical questions of conservation, preservation, and management of habitats being so important, quantitative bird population information becomes even more critical. A compilation and synthesis of data from many sources including systematic censuses and surveys, banding, one-day and roadside counts, tower kills, and casual observations are needed. Much of the existing information is not organized by vegetation type but rather covers a mosaic of types in a region.

Data from this study provide seasonal density estimates for 5 major habitats found in west-central Florida. Species richness and habitat associations followed expected patterns with fewer species observed in vegetatively simple habitats and more species occurring in habitats exhibiting considerable vegetative-structural diversity. Avian species richness and density in the unimproved pasture type were lower than that for the Manatee County pine flatwoods study (Hitch and Marion, 1979) probably because of more frequent burning of the range and heavier grazing pressure. Densities of pine trees were similar (33 vs 28/ha) for the 2 study areas.

The importance of the various vegetation types to each bird species is evident from the data. As land management practices in central Florida continue to change, particularly as native range shifts to cropland and improved pasture, many short-term and long-term changes in bird populations will occur. Diversity or species richness probably will diminish, and populations of adaptable species, some of which may be potential nuisances, will increase. More quantitative studies are needed to document these changes.

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Biological Sciences

ALLELOPATHY OF WAX MYRTLE *(MYRICA CERIFERA)* ON *SCHINUS TEREBINTHIFOLIUS*

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ABSTRACT: *Nutrient solution leached through soil in which wax myrtle was rooted inhibited growth of schinus. Aqueous leaf extracts of wax myrtle leaves inhibit germination of beans, and possibly of schinus. Allelopathy by wax myrtle reduces the vigor of schinus, and may increase its susceptibility to competitors and pests. Because of the ecological similarity of wax myrtle and schinus, encouragement of myrtle growth may be an effective biological control tool.*

SCHINUS TEREBINTHIFOLIUS Raddi (schinus, Brazilian pepper, Florida holly), of the Anacardiaceae, is an exotic shrub which has been very successful in colonizing many areas in South Florida. It is a sprawling, evergreen, dioecious species, usually 3 to >6 m tall. Females bear bright red berries, 5 mm in dia, which begin to ripen in November; these make the plant highly priced as an oranmental. Seeds are dispersed by several species of birds (Nehrling, 1944) and mammals. The shrub is most abundant on disturbed sites, but is also found in mature plant communities (Duever et al., 1979). Schinus is native to Brazil, Paraguay, and northern Argentina (Krauss, 1963), and is now grown in many other tropical regions as an ornamental. It was introduced to Florida from Brazil around 1892 (Hilsenbeck, 1972) and the seeds were widely distributed for plantings.

The Hole-in-the-Donut section of Everglades National Park is a 6,883 ha area of which 3,644 ha were farmed. Agriculture began in the early 1900's and continued on some parts until July, 1975. Native biotic communities were completely removed from about 2,429 ha through row cropping and rock plowing (Resource Management Staff, 1976). Schinus probably entered the park in the 1940's (Bancroft, 1973), and quickly became established in the Hole-in-the-Donut when agriculture was abandoned. It has formed several dense stands which exclude understory growth and prevent other species from spreading. Once established, the plants survive fire or cold-kill of tops by vigorous basal sprouting.

Attempts to control schinus have met with little success, although some herbicides are effective in killing it. Biological control experimentation with insects native to Brazil and found on schinus there was carried out in Hawaii, where schinus is an important weed of rangelands, with no significant results (Krauss, 1963).

One of us (J. Ewel) is conducting a study of schinus in the Hole-in-the-Donut. One of the sites under investigation is a former pineland, last farmed about 18 yr ago, on which wax myrtle, *Myrica cerifera* L. (Myricaceae), has become dominant. The understory is open, even though there are large schinus trees in the area which serve as a seed source. Measurements indicate a significantly lower growth rate of naturally occurring schinus seedlings in the wax myrtle stand than in the other 4 sites being monitored. These data, plus field observations that showed seedlings to be spindly and unhealthy-looking, led to the hypothesis that wax myrtle might be allelopathic to schinus.

Wax myrtle is a widespread, native, evergreen shrub or small tree found in many environments in Everglades National Park (Craighead, 1971). Wax myrtle often reaches heights of 13 m or more, and grows in association with other woody species (Green, 1939; West and Arnold, 1946). The blue-gray berries, 2 to 3 mm in dia, ripen in September and remain until spring. Birds like them (Green, 1939) and wax from the berries is used by people for medicine, soap, and candles. The leaves and bark are said to have astringent properties (Harper, 1928). The leaves are covered above by minute dark glands, below by orange-colored glands, and have a distinctive balsamic resinous odor when crushed. The trunks may grow to 30 cm in dia and the bark is about 6 mm thick. Wax myrtle bears root nodules containing symbiotic, nitrogen-fixing actinomycetes (Bond, 1976).

Allelopathy is the process by which a plant releases into the environment a chemical compound which inhibits the growth of another plant in the same or a neighboring habitat. It differs from competition in not involving the depletion of a necessary factor in the environment and in depending upon the addition of a deleterious factor (Muller, 1969). Allelopathy may function by one of a number of mechanisms, including auxin oxidation inhibition, the retardation of photosynthesis, and interference with mineral uptake, to name a few. The incidence of chemical inhibition has been demonstrated to be higher in plants from arid regions than in those from humid regions (del Moral and Cates, 1971); however, allelopathy appears to play an important role in altering the structure, function, and diversity of plant communities in many natural and agricultural communities throughout the world.

Experimentation has shown allelopathy to be an important factor affecting plant succession. Certain allelopathic agents inhibit seed germination of some species (Abdul-Wahab and Rice, 1967). Rice (1971) suggested that low-nitrogen-requiring early plant invaders might produce inhibitors of nitrogen-fixing and nitrifying bacteria. He tested 24 species of plants of importance in revegetating old fields against *Azotobacter*, *Rhizobium*, *Nitrobacter*, and *Nitrosomonas*, and found considerable activity was exhibited against most of the test bacteria by 12 plant species.

Several aromatic shrubs were found by Muller, et al. (1964) to produce volatile allelopathic inhibitors. Indications are that these function by rainfall and dew picking up toxic substances from the leaves and transporting them to the ground. Wax myrtle might do the same.

We designed experiments to test the possibility that wax myrtle may produce one or more allelopathic substances that inhibit germination and/or growth of schinus.

MATERIALS AND METHODS—The effects of wax myrtle exudate on schinus seedlings were investigated using an experimental design modified from Wilson and Rice (1968). Wax myrtle plants, about 0.5 m tall, were obtained from a local nursery. Beans, *Phaseolus vulgaris* L. var. Tendergreen (Fabaceae), were selected as a control because they participate in a symbiotic nitrogen-fixing relationship, as does wax myrtle, and theoretically would have similar nutrient requirements. Schinus seeds were collected from the Hole-in-the-Donut area in December, 1978.

Schinus and beans were planted on 16 January and grown in clean builder's sand with a dilute commercial plant food solution (Ortho 12-6-6). On 11 February the bean plants were transplanted into clean builder's sand in 14 cm dia, glazed clay pots, one plant per pot. On the same day, the wax myrtles were transplanted, one per pot, into the same kinds of pots used for the beans, but the root ball and nursery soil were left intact because we thought they might be a source of allelopathic substances produced by the myrtle. From then until the end of the experiment the beans and wax myrtles were watered and fertilized with a complete nutrient solution (Ross, 1974). On 14 April schinus seedlings were transplanted into clean builder's sand, 3 into each of 14, 10.4 cm dia, glazed clay pots. The experiment began on 16 April and ran for 36 da.

Each myrtle was randomly paired with a bean. Pots containing schinus were randomly assigned to either a wax myrtle or a bean. The experimental setup consisted of 4 tiers of shelving, arranged stair–step fashion to minimize shading, in a greenhouse. The uppermost shelf contained one-liter plastic bottles, one for each myrtle or bean plant, which acted as nutrient-solution reservoirs. The next shelf contained the randomized pairs of pots, wax myrtle alternating with bean. The third shelf contained the pots holding schinus. The lowest shelf contained another set of reservoir bottles. Each container was connected to the plant below it with plastic tubing terminating in a small pipette to insure slow flow. The exteriors of all reservoirs, tubing, and pipettes were painted to inhibit algal growth.

About 900 ml of nutrient solution were placed in the uppermost reservoir, and the flow was adjusted with a screw clamp so that it took about 5 hr for the reservoir to empty. The nutrient solution trickled onto the substrate surface in a pot containing wax myrtle or bean, then flowed out of the bottom of those pots, and trickled down onto the substrate surface in the pots containing schinus. From there it flowed out of the bottom of the schinus pots and was collected in the lower reservoir. Each morning the nutrient solution from each collector was brought back up to 900 ml by adding fresh nutrient solution. The solution was then poured back into the upper reservoir from which it had originated, and the cycle was repeated.

Heights of the schinus and number of leaves per plant were monitored every 2 to 4 da. At the end of the experiment the schinus plants were removed and their stem lengths, root lengths, number of leaves, and oven-dry weights of roots and above-ground parts were recorded. Data were analyzed for each variable using a paired "t" test.

We also tested the effect of aqueous wax myrtle leaf extracts on the germination of schinus seeds. Wax myrtle leaves were collected from the Hole-in-the-Donut on 29 December and stored for 2 mo in a plastic bag. An extract was prepared by boiling 10 g fresh weight of leaves for 5 min in deionized water and grinding in a blender for 10 min at high speed. The solution was allowed to stand for 15 min, then filtered by gravity through Whatman No. 1 paper with a Büchner funnel in a refrigerator. Final volume was brought to 120 ml with deionized water.

Schinus seeds were planted about halfway into about 3 mm of clean builder's sand, with 50 seeds per Petri plate in 20 plates. Ten plates were saturated with leaf extract and 10 with deionized water. The plates were randomly placed on a greenhouse bench. The number of germinated seeds was counted daily and each was removed as its hypocotyl appeared. Two such trials were run.

Experimenters in the past have used fast-growing, easily obtainable plants to quickly test allelopathic effects on germination and growth (e.g., del Moral and Cates, 1971). Beans of the same variety used for the stair-step experiment were chosen for this purpose. Fourteen Petri plates were filled with vermiculite and 5 beans were planted in each plate. Seven randomly chosen plates were moistened with nutrient solution and the other 7 were moistened with wax myrtle extract. The extract was made with leaves obtained from local (Gainesville vicinity) wax myrtle bushes. One liter of cold nutrient solution was added to 50 g fresh weight of leaves and refrigerated for 48 hr. The solution was then strained and stored in a refrigerator overnight, but was warmed to room temperature before application to beans.

Osmolality of the wax myrtle solution was measured with an osmometer (Fiske Model 330 D) and its value was 14 milliosmols/kg, which is too low to have any significant effect on germination by causing osmotic movement of water from the beans into the substrate. The plates were placed in an incubator with a constant humidity of 50%, an 11.5-hr period of darkness with a temperature of 20°C, and a 12.5-hr period of light with a temperature of 30°C. They were removed after 51 hr. Germination rates were noted and hypocotyl lengths of germinated seedlings were measured.

Results and Discussion—Mean measurements of schinus under wax myrtle were, in all cases, smaller than those under beans (Table 1). Leaf production was significantly ($p < 0.01$) less, with averages of 5.8 schinus leaves under myrtle and 7.3 leaves under beans. Figure 1A shows the pattern of leaf production for the 32 da during which measurements were taken. The most divergence occurred between the day of the first count (day 2) and 18 da afterwards. The greatest growth lag in schinus under wax myrtle occurred at the onset. All schinus seedlings had been transplanted into their pots 2 da before initiation of the experiment; the schinus under wax myrtle may have had more difficulty overcoming transplant shock as a result of the effect of an inhibitory compound. From day 18 to day 30 the leaf productions were about the same, but diverged again during the last 2 days.

Table 1. Mean values of characteristics of schinus growing under wax myrtle and under beans. Significant differences (* indicates $p < 0.05$; **indicates $p < 0.01$) were determined using paired, two-tailed "t" test ($n = 7$).

Characteristic of Schinus	Under bean (Control)	Under Wax Myrtle	Difference (Control - Wax Myrtle)
Number of leaves	12.8	11.3	1.5
Leaf production (no./32 days)	7.3	5.8	1.5**
Stem length (mm)	214	189	25
Stem growth (mm/31 days)	122	99	23
Root length (mm)	172	155	17
Stem weight (mg)	47	33	14 **
Root dry weight (mg)	12	7	5
Total dry weight (mg)	59	40	19 *

Height growth followed a similar trend, but for different time periods (Fig. 1B). However, mean values for growth rates of schinus under wax myrtle and under beans (controls) during a 31-da period were not significantly different ($0.5 < p < 0.10$). Stem weights differed significantly ($p < 0.01$), as did total weights ($p < 0.05$), but root lengths, root weights, total numbers of leaves, and stem lengths were not significantly different.

There was an unidentified leaf-spot disease, probably a fungus or a virus, in the schinus plants before they were introduced to the stair-step apparatus. At the end of the experiment the schinus under wax myrtle showed a high incidence of the disease (13 of 21 plants had at least a few spots) and had more insect damage. The schinus under beans showed very little disease;

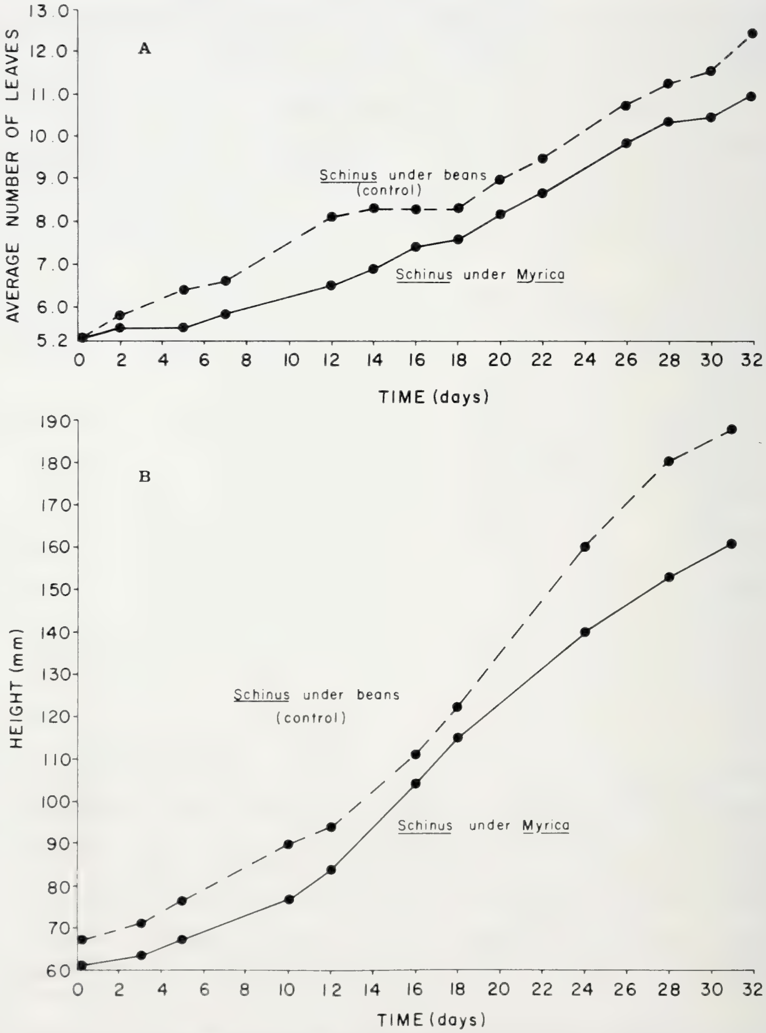

FIG. 1. Growth of schinus seedlings exposed to solution from wax myrtle plants (tests) and from bean plants (controls). Each point is a mean of 21 schinus. A. Leaf production. B. Height growth.

only 2 plants had spots. Inhibition may function by weakening plants, making them more susceptible to disease.

An average of 79 ml more nutrient solution was added to each wax myrtle plant per day than to each bean. This additional amount was necessary because the wax myrtle plants had more roots and more leaf surface than the beans, thus they evapotranspired more. More nutrients may have reached the schinus under wax myrtle, so if any growth stimulation occurred as a result of nutrient availability, it would have been greater under the test plants (myrtle) than under the controls (beans). Nutrient levels were probably not high enough to be toxic.

In the first germination trial, the test plates were treated with leaf extract throughout the experiment. The germination rate of schinus seeds treated with deionized water (controls) was 3.6% and that of seeds treated with wax myrtle extract was 1.2%. In the second trial, wax myrtle extract was administered less often; the sand was kept moist between applications with deionized water in an attempt to increase germination rates in all plates. Germination rates were slightly higher: 4.2% in the control plates and 3.0% in the test plates. Differences were not statistically significant in either trial, however, probably because of the extremely low overall germination. The highest germination rate observed in any Petri plate was 10%, while the average rate in controls for both trials was only 3.9%. The greenhouse environment may not have been humid enough; the Petri plates were not airtight and evaporation from the sand occurred quickly, so the seeds were exposed to daily fluctuations of high moisture followed by dryness. A germination test of 400 schinus seeds from the same 1978-79 seedlot was conducted under environmentally controlled conditions and we observed 21% germination.

Unlike germination of schinus seeds, germination of bean seeds was significantly lower ($p < 0.05$) when they were treated with wax myrtle extract. Germination of controls was 94%; that of beans treated with the extract was only 63%.

The mean hypocotyl length of the bean seeds treated with wax myrtle extract was greater (42.5 mm), but not significantly so, than the mean hypocotyl length of controls treated with nutrient solution (36.3 mm).

Wax myrtle clearly has an allelopathic effect. Although the magnitude of growth inhibition is not as great as that reported for many other species (e.g., Wilson and Rice, 1968), it may be significant in influencing the vigor of species such as schinus in successional South Florida ecosystems. Any reduction in schinus vigor is likely to make it more susceptible to being outcompeted, reduce its reproductive potential, and increase its susceptibility to herbivores and diseases. Schinus and wax myrtle have similar growth forms, and both species are conspicuous invaders of abandoned farmlands in South Florida. Therefore, management practices which favor the development of our native wax myrtle are likely to simultaneously assist in the control of the exotic schinus.

ACKNOWLEDGMENTS—We thank Faye Benedict, who first called our attention to the potential allelopathy of wax myrtle on schinus. This study was supported by U.S. Dept. of Interior, National Park Service contract CX528081921 with J. Ewel, "Successional Ecosystems and Exotics in Everglades National Park."

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Biological Sciences

PARTICLE BREAKDOWN OF RECENT CARBONATE SEDIMENT IN CORAL REEFS

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ABSTRACT: *Skeletal particles of the major components of the carbonate sediment of the reef shoal environment were examined using the scanning electron microscope. This examination revealed no set pattern of skeletal breakdown according to microarchitectural structure, as postulated by the Sorby principle, but that such a breakdown depends on mineralogical composition, wall thickness, grain size and pattern, density, and the amount of cementation and bioerosion. To investigate general particle-size abundances and deficiencies in carbonate sediment, samples were taken from the reef crest, back-reef rubble and open-sand ecozones of the reef shoal environments of sites from the Bahamas, Dry Tortugas, Lower Florida Keys, Grand Cayman Island and the U.S. Virgin Islands. Size analyses of these samples showed that the sediment is moderately well-sorted, coarsely-skewed and leptokurtic. Although particle-size abundances (or modes) exist in each individual site, there is no particular particle-size abundance that is common to all the sites. It is inferred that the particle abundances (or modes) for each site are a product of the sorting potential of the wave energy and that this sorting potential is the major control of the breakdown of sand-sized skeletal particles rather than the microarchitectural structure as proposed by the Sorby principle.*

AN ORGANIC REEF is the visible result of the complex interaction of many processes. The approaches which various researchers have used to define reef processes have been varied as the processes themselves. My investigation is restricted to constituent grains and grain-size parameters of the skeletal component of sediment from the reef shoal.

Skeletal breakdown has interested many workers since Sorby (1879) first recognized the possibility of obtaining different sized constituents from the product of skeletal disintegration. He stated that "When a shell decays by removal of the organic matter, there is a manifest tendency to break-up into the ultimate crystalline constituents". This relationship between the breakdown of the skeletal material to the nature of their microstructure is known as the Sorby Principle (Folk and Robles, 1964).

In applying the Sorby principle to the breakdown of *Halimeda* Jindrich (1969) reported a departure from the modal size values of various constituents of carbonate sediment found by Folk and Robles (1964). Jindrich postulated that the breakdown of *Halimeda* is partly a function of the sorting potential of a given environment rather than a structural characteristic. He noted that coarse sediment will predominate in a community of organisms with rapid carbonate production and short life spans, while finer sediment is found in communities with slow production and long life spans. I interpret these conclusions to be applicable to a community of skeletal species with a high resistance to fragmentation in the case of coarse sediment, and a low resistance to fragmentation in the case of fine sediment.

When studying carbonate sediments, many researchers have assumed that size distribution is a function of the skeletal size and the distribution of the organism that produced it, while the constituent composition is a function of the hydrodynamic conditions which effect the grain size distribution. I believe that various sizes of skeletal particles are disseminated primarily by physical processes alone, and not according to the geographic distribution of the producing organism because skeletal particle distribution of the major constituents is an artifact of the various processes of skeletal breakdown. These skeletal breakdown processes are responsible for the original particle size variations in sediments. Ginsberg (1956) has noted that reliance on a single organism as an indicator of a zone or environment is likely to produce misleading information if that organism is considered as part of a total sample count. To avoid such an influence on the whole sample, I propose that a more reliable method would be to compare the ratios of the relative percentages of 2 or more organisms which should be present in significant amounts in each sample.

For example, the ratio of coral: algae may be used as an indicator of the reef zone (Feazel, 1975); and the mollusc; coral ratio for the Reef Shoal environment (Swinchatt, 1965).

METHODS—Five study areas were selected: Water Island, U.S. Virgin Islands, Grand Cayman Island, the Dry Tortugas, Green Turtle Cay in the BAhamas, and the Lower Florida Keys. Samples were taken along transects through the reef crest, back-reef rubble, and open-sand zones that make up the reef shoal environment. By including many sites from different areas, it was hoped that any bias in special environmental conditions that may occur in a single area could be reduced. It was also done in an effort to examine different sorting potentials that may affect the breakdown of skeletal particles.

Each sample was dry-seived through 1/4 phi sieves, and the sedimentary statistical parameters were computed on a DCD 6600 computer using the GRANULO Fortran IV program (May, 1973). This program calculates the moment measures, a size-weight cumulative probability curve, and a size-weight frequency distribution. The moment measures are the mean, standard deviation, skewness, and kurtosis. These 4 measures are thought to reflect the physical conditions existing at the time (or shortly before) sampling. It is proposed that a size-weight cumulative frequency curve may permit a study of the energy-level—the processes of erosion, transportation, and deposition—and the availability of the material.

RESULTS—A general plot (Fig. 1) of all the samples according to their zones shows that the mean size ranges from -0.5 phi to 1.8 phi (moderate to very good sorting). These results agree very closely with those of other researchers who studied comparable sediments (Feazel, 1975; Roberts, 1976; Hoskin, 1966; Folk and Robles, 1964).

Another bivariate plot of skewness and standard deviation is considered to be an indicator of local grain size availability (Stapor and Tanner, 1973).

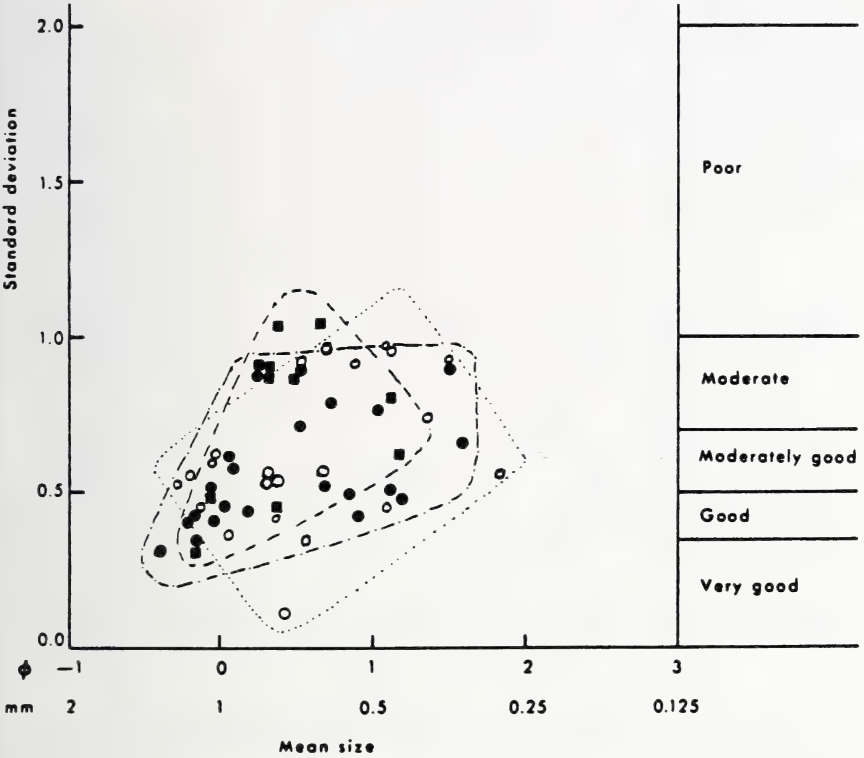

FIG. 1. A bivariate plot of the mean vs. the standard deviation for all the samples from the Reef Shoal environment: ○ = back-reef rubble zone, ● = open sand zone, ■ reef crest zone.

From this plot (Fig. 2) the 3 zones overlap considerably, but are centered around zero skewness, with the reef crest zone skewed toward the coarse. This indicates that in all 3 zones, the source material is similar.

A bivariate plot of kurtosis versus standard deviation shows no distinct clustering and considerable overlapping of all 3 zones (Fig. 3). This lack of clustering is not surprising because the bivariate plot of skewness versus standard deviation has shown that the source material is the same. This plot also shows there is a definite biogenic environment for this energy area of the reef shoal environment.

An examination of the plots of the cumulative weight percent versus the mean size shows a very low concentration of the fine-grained sediments in all samples. This may be due to the effect of the waves and currents washing out and transporting the fine grains away from the reef shoal environment.

Folk and Robles (1964) reported an abundance of particles in the sizes of -6 to -5 phi, -1 to +1 phi and 1.5 to 2.5 phi and a deficiency in the intermediate sizes of samples from Alcaran Reef, Yucatan. Stoddart (1962) has observed similar modes in sediment from Belize cays, but Jordan (1973)

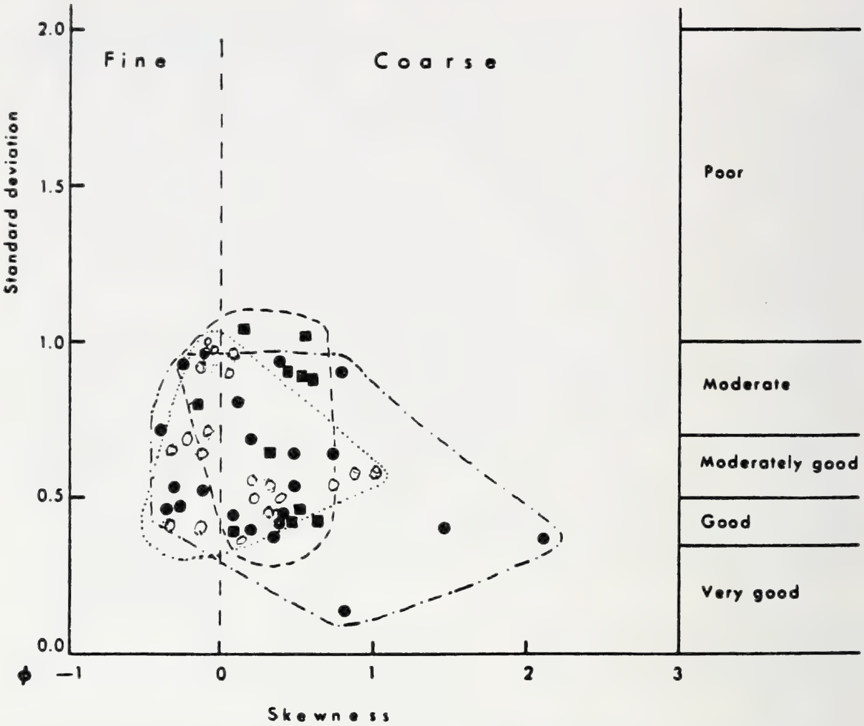

FIG. 2. A bivariate plot of the standard deviation vs. the skewness of all the samples of the Reef Shoal environment.

reported 2 major modes of -5 phi and 0 to 1.5 phi in sediments from Bermuda. Folk and Robles (1964) explained the aforementioned particle abundances and deficiencies in the phi sizes as being due to the manner of breakage. They consider the breakdown of the particles to be controlled by their architecture and explained the abundance of particles of *Acropora cervicornis*, for example, in the -6 phi size as a function of its brittle nature and its fracturing within 1 cm of the juncture point of the branches. The grain size of the 2.0 phi coral grit is considered to be produced by abrasion and is controlled by the fibrous crystals of the skeleton.

My results show there are different modes in the sediment for each site area (Fig. 4). A particle size "deficiency" does, however, seem to exist for all the study areas at the -0.375 phi sizes, but it is thought that this size "deficiency" is relative to the size abundances and not to the actual constituents of the samples, and so cannot be termed a true deficiency.

SEDIMENT COMPOSITION ANALYSIS—The scanning electron microscopic (SEM) examination of particles of the main constituents of the sediment of the reef shoal environment has shown no particular breakage pattern. Disarticulation of the skeleton occurs as plates, spines and sticks, but there is no pattern to further breakdown into smaller particles. The breakdown of the

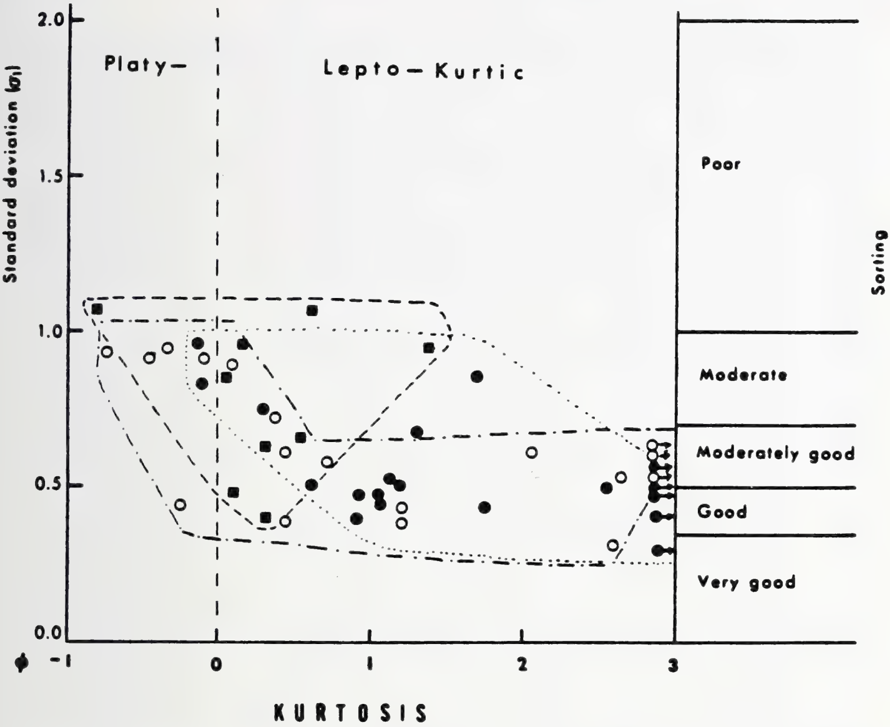

FIG. 3. A bivariate plot of the standard deviation vs. the kurtosis of all the samples of the Reef Shoal environment.

particles in the reef shoal environment after its death depends on the manner or degree of destruction of the surface organic membrane and the amount of exposure to bioerosion. Bioerosion is the major factor of mechanical breakdown in the reef shoal environment both on the macro- and the micro-levels. A field experiment conducted by the author in the reef shoal environment of the Lower Florida Keys has shown that the first sign of bioerosion on a surface of a mollusc shell occurs after only 49 hrs, and that boring through the shell by a predatory gastropod was completed 157 hrs after being placed in the reef crest zone. Abrasion is not considered an important factor under the normal wave conditions of this environment based on the SEM examination of the various particles. An organism's skeletal material's resistance to breakdown depends primarily on bioerosion and then on the mineralogical composition, wall thickness, density, microarchitectural grain size and pattern, and the amount of recrystallization of the particle.

An examination of the various constituents was made to determine if the modes for each site area depend on the particle breakdown of each major constituent. The relationship between size and type in carbonate sediments has been proposed by Sorby (1879) and by Folk and Robles (1964), while Hoskin (1966) proposed that this relationship explained the same size breakdown found in different coral genera and *Halimeda* in sediments from

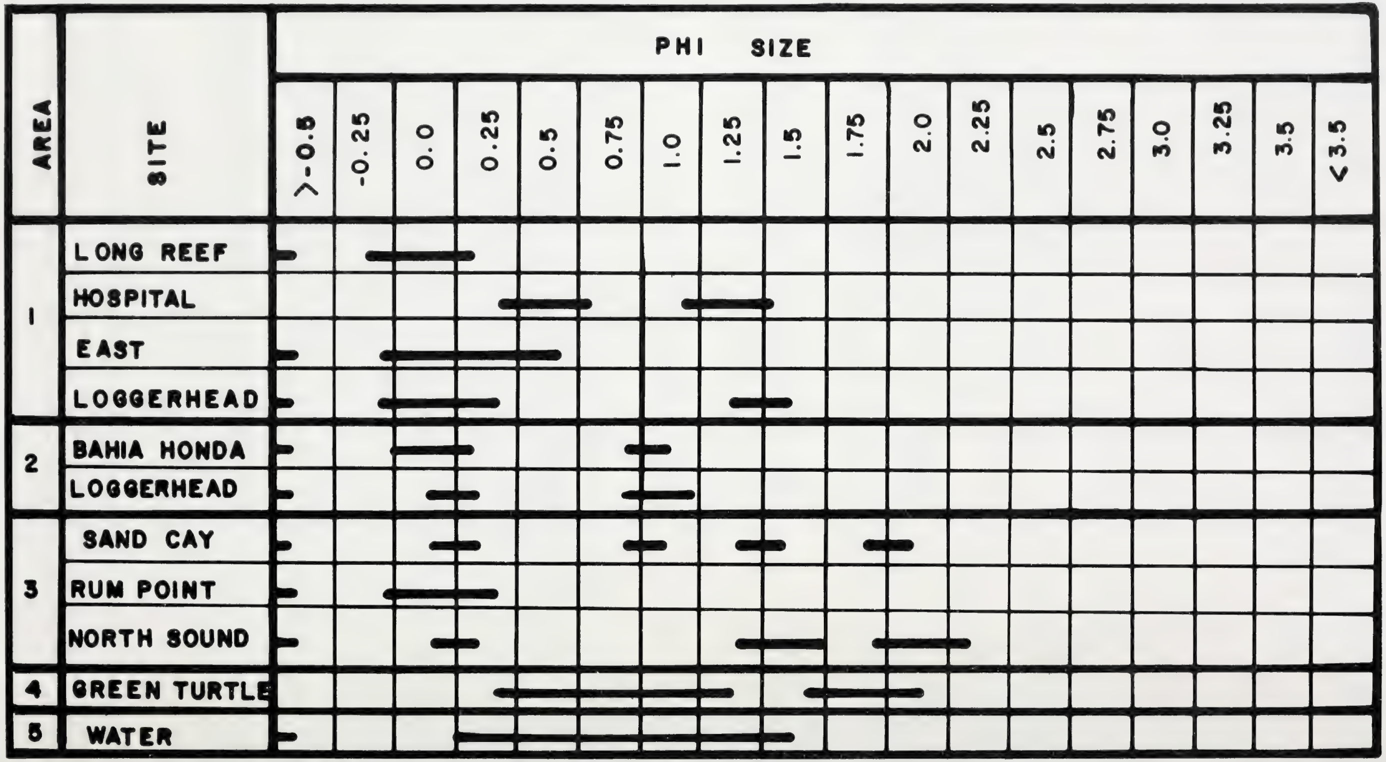

FIG. 4. particle abundances (or mode) in the Reef Shoal environment from each site area: (1) Dry Tortugas, (2) Lower Florida Keys, (3) Grand Cayman Island, (4) Green Turtle Cay, Abaco, and (5) Water Island, U.S. Virgin Islands.

the beach and lagoon pinnacles of the sediment of Alacran Reef, Yucatan. Jindrich (1969), however, found a large departure from these modal sizes by examination of the carbonate sediment of the Lower Florida Keys and concluded that the abundance is at least partly a function of the sorting potential of a given environment rather than resulting weight from structural characteristics. Other departures from the modal sizes proposed by Folk and Robles (1964) are recorded in the literature and are presented in the following examination of each major constituent of the sediment from the reef shoal environment. Folk and Robles (1964) showed that *Halimeda* tended to concentrate in modal breakdown ranges of coarse sand to granules (-1.0 to 1.0 phi). Bramlette (1926) also showed a similar size concentration in the sediment from American Samoa. Emery (1962), Hoskin (1966), and McKee, et al. (1959) have shown that the average plate size of *Halimeda* is -1.0 phi. Stoddart (1962) found that *Halimeda* plates had a mode of 0.0 phi in the Honduras, and the same mode was found by Jordan (1973) in his study of the Bermudan sediment. However, Upchurch and McKenzie (1968) and Maxwell et al. (1964) found a modal size of 0.0 to 1.0 phi from Bermuda and Australia, respectively, while Fosberg and Carroll (1965) have reported a plate range of -3.5 to 2.0 phi in the sediment of the northern Marshall Islands. The results of my study show that the range of *Halimeda* plate sizes vary slightly for each study area. In the Bahamas, the Dry Tortugas and the Lower Florida Keys, the plate sizes range from -1.125 to -0.875 phi, while in the Cayman Islands and Water Island the range is from -1.0 to 0.75 phi. I believe these differences can be accounted for by the different rates of production of the carbonate skeleton and the mortality rate of the individuals in the different areas.

Different modal sizes of coral have been reported in the literature. Folk and Robles (1964) reported the modal sizes of -7.0 phi and 2.0 phi, while Jindrich (1969) found a size of 1.75 phi. No particular modal size of the scleractinian corals or the gorgonians can be discriminated in a plot of all the sites in this study.

No preferential modal size of echinoid particles or foraminifera was found in this study. In most of the samples, the foraminifera tests tended to be complete in the sizes greater than 3.0 phi, while fractured and broken specimens were common in less than 3.0 phi sizes. Jindrich (1969) reported a modal size distribution in 0 phi to 1.0 phi size fraction in the sediment of the Lower Florida Keys, while Folk and Robles (1964) found a modal size of 0.5 phi in the sediment from Alacran.

Jindrich (1969) found that mollusc fragments do not show any particular size preference in the sediment of the Lower Florida Keys, but Bramlette (1926) reported a particle size concentration of -0.5 phi in the sediment from Pago Pago Harbor, Samoa. Folk and Robles (1964) found 2 modal sizes of -2.0 phi and 1.0 phi in the sediment from Alacran, and Jordan (1973) reported a -3.0 phi size in the sediment from Bermuda. This study agrees with the findings of Jindrich (1969) that there are no particular modal sizes in the breakdown of mollusc shells.

Previous researchers (Jordan, 1973; Jindrich, 1969; Feazel, 1975) have been able to discriminate some ecozones in a particular environment on the basis of the variations of the average percent compositions of the constituent particles. By comparing the major constituents, such as algae-coral, to one another using the computer program TRIGRAM, a plot was made for each zone using the average zone sample for each area. It was found that in all cases each zone overlapped each other zone and in all cases the reef crest zone was encompassed by the other 2 zones. This is to be expected because most of the source material has originally come from this particular zone.

CONCLUSIONS—The microparticles of the sediment of the reef shoal environment using the SEM showed no particular breakage pattern in any of the main constituents. Breakdown of the reef zone organisms, however, does depend, initially, on the destruction of the organic surface membrane and on the amount of bioerosion. Each organism's resistance to skeletal breakdown also depends on mineralogical composition, wall thickness, density, microarchitectural grain size and pattern and the degree of cementation of the particles.

The marine sediment of the reef shoal environment tends to be moderately well-sorted, coarsely-skewed and leptokurtic. The phi-size particle abundances for each site area is a product of the sorting potential of the wave energy level in the reef shoal environment, instead of being controlled by the microarchitecture of the skeletal material as postulated by the Sorby principle.

The percent composition of the major components of the sediment for each phi size showed no modal sizes that are common to all the study sites. The ecozones of the reef shoal environment cannot be discriminated on the basis of the ratios of the major components.

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Physical Sciences

BURIED SOILS IN THE APALACHICOLA NATIONAL FOREST, FLORIDA

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Abstract: *Several buried soils were found in the Apalachicola National Forest in the Florida panhandle. In 2 of these, wood fragments from gymnospermous plants (probably bole) occurred at depths of 1.5 to 1.8 m in a buried soil. These were dated at 4,280 and 7,110 yr old. We believe the mechanism of burial was by aeolian transport and that a xerophytic environment occurred during the period of burial.*

Apparent buried soils are frequently encountered in the Apalachicola National Forest in the Florida panhandle and have been noted in the literature (Clewell, 1971; Coultas et al., 1979). These are recognized as dark-colored subsurface horizons, relatively high in organic matter. Uncertainty sometimes exists if these horizons were ancient surface soils subsequently buried by the action of wind or water or that they are the result of pedogenesis. Soils with spodic horizons, subsurface accumulations of organic matter and aluminum, are common in this area. These horizons are formed by downward leaching of organic material from surface soils to the water table where accumulation takes place. These deposits are usually cemented and have a redder hue than buried surface soils.

Coultas et al. (1979) reported wood fragments, presumably bole, in what appeared to be a buried soil about 19 km southwest of Tallahassee. We present C-14 dates on wood from 2 soils sampling sites at this location and discuss these dates along with other evidence in an attempt to explain the origin of these soils.

Study Area—The study sites were located within the Apalachicola National Forest in southwestern Leon County, Florida (Fig. 1). Buried soils were discovered at the 16, 30, 37, and 52 m sites. Three sites were studied at the 30 m location. Two sites that were 60 m apart contained wood fragments. The third site was about 0.8 km to the east.

Figure 1 also shows certain physiographic features that are germane to a discussion of the origin of the buried soils. The 15 m contour roughly indicates the divide between a karst region of well-drained sandhills and a relatively flat region of pine flatwoods and acid swamps. The sands on the surface of the latter area are underlain by impermeable clays which prevent the percolation of water into the limestones beneath. A few minor streams drain part of the flatwoods region, carrying waters high in tannic acid into the appreciably lower elevations of the sandhill region. Lost Creek and some

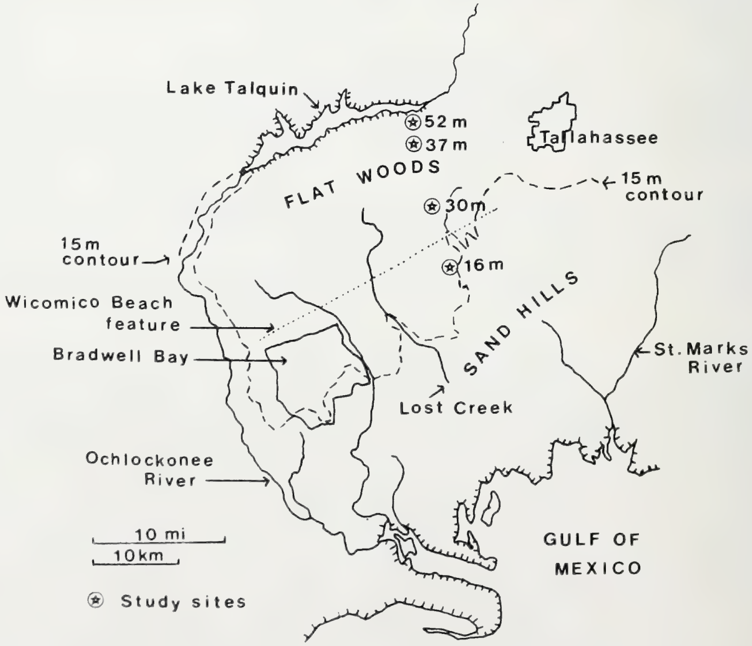

Fig. 1. Location of the study area in North Florida.

other streams go underground upon reaching karst topography (Hendry and Sproul, 1966).

The only important river in the vicinity is the Ochlockonee, which has an average discharge of 457 hl sec near the dam at Lake Talquin. The next largest is the St. Marks River which has an average discharge of 189 hl sec near the coast and much of it is contributed by the spring-fed Wakulla River (USGS, 1973).

Pleistocene interglacial sea levels reached about 8 m above present sea level (Alt and Brooks, 1965). The 8 m contour is inland and lies near the 15 m contour line. A low, nearly imperceptible ridge was identified by Puri and Vernon (1964) as a relic beach feature of the Wicomico shoreline dating to the late Miocene . A large acid swamp, Bradwell Bay, where the vegetation consists mostly of titi, bay, and blackgum, lies just south of this old shoreline (Hebb and Clewell, 1976).

METHODS—Soils were examined and described using procedures outlined by the Soil Survey Staff (1951). Particle size analyses were performed following procedures of Day (1965). Heavy minerals were separated from the fine sand fraction using bromoform (sp. gr. 1.9) after the organic matter was removed with H_2O_2 and sands were fractionated by sieving. Organic C was determined using the Walkley-Black procedure (Jackson, 1958). Age estimations, using the C-14 method, were made on buried wood fragments by Teledyne Isotopes of Westwood, New Jersey, for site 1 and by the Department of Geology of the University of Miami, Florida, for site 2. Wood sections were identified by microscopic examination by Dr. L. C. Anderson at Florida State University.

RESULTS—The results of the soils analyses are in Table 1. Additional soils parameters for sites 1 and 2 are in Coultas, et al. (1979). The soils at site 1 were Psammaquents and supported longleaf pine-saw-palmetto flatwoods vegetation. The soil at site 2 was a Haplaquod and contained a titi swamp.

The soils at all 6 sites were of sandy texture. The organic C increased in the buried soil over that in the lighter-colored upper horizons without exception. The fine sand/sand ratios suggest a different mode of deposition or different conditions of deposition except with the soil at site 4. This evidence is also supported by differences between the fine sand-heavy mineral/fine sand ratios. Sand grains were rounded and pitted, suggesting both water and wind transport.

Although there was little change in texture, there was an abrupt change in color between the A2 and A1b horizons at site 1 and the C horizon and A1b at site 2. Colors changed from a light-gray in the A2 to brown at the top of the buried soil at site 1 and from a light brownish-gray in the C to dark-gray to black in the A1b horizon at site 2.

Wood fragments were in both profiles in the upper, dark-colored horizons of the buried soils. Gymnospermous wood occurred at depths of 150-175 cm and was 4,280 ± 95 yrs old at site 1. Wood identified as pine occurred at depths of 150-180 cm and was 7,110 ± 90 yrs old at site 2. An in-

Table 1. Some physical and chemical properties of some buried soils.

Location	Approximate Elevation, meters	Horizon	Depth cm	Sand	Silt	Clay	Fine sand	Heavy mineral	Organic	Buried
				%	%	%	%	%		
				a	a	a	b	c	a	
NW 1/4, Sec 34	30	Ap	0-10	95.4	2.6	2.0	23.4	0.17	0.54	
R2W, TIS		A24	66-104	93.0	4.0	3.0	26.8	1.29	0.06	
Site 1		A25	104-150	95.4	2.6	2.0	26.4	1.30	0.04	
		A11b	150-160	89.1	6.9	4.0	20.8	3.09	0.07	X
		A12b	160-178	87.2	4.8	8.0	20.7	2.47	0.14	X
NW 1/4, Sec 34	30	Ap	0-15	97.0	0.0	3.0	20.8	0.06	0.96	
R2W, TIS		B22h	102-112	95.4	0.0	4.6	24.6		0.34	
Site 2		C	112-122	90.1	3.9	6.0	24.5	0.40	0.22	
		A12b	137-152	89.7	1.7	8.6	17.6	0.86	0.67	X
		A13b	152-183	95.1	0.0	4.9	18.2	0.84	2.04	X
SW 1/4, Sec 32	52	A2	140-152	99.5	0.0	0.5	32.8	2.37	0.02	
R2W, T1N		A1b	190-203	96.7	0.0	3.3	28.7	3.47	0.08	X
Site 3										
SE 1/4, Sec 6	37	A2	140-152	96.4	1.1	2.5	35.4	0.68	0.02	
R2W, T1S		A1b	190-203	96.6	0.9	2.5	35.7	2.87	0.06	X
Site 4										
NE 1/4, Sec 34	30	A2	198-213	94.6	2.9	2.5	27.2	0.83	0.02	
R2W, T1S		A1b	234-264	96.5	0.0	3.5	14.2	0.93	0.08	X
Site 5										
SW 1/4, Sec 24	16	A2	183-198	94.0	2.5	3.5	52.1	0.21	0.01	
R2W, T2S		A1b	229-234	94.5	1.0	4.5	47.4	0.24	0.25	X
Site 6										

a. Numbers represent percentages. b. Percentage of fine sand in the sand fraction. c. Percentage of heavy minerals in the fine-sand fraction.

tact tree stump was discovered at site 2 with its trunk extending to 125 cm of the current surface.

Discussion—The morphological differences between the soil horizons and the presence of buried wood, particularly the intact bole, suggest that the Ab horizons of site 1 and 2 represent a buried soil, rather than one resulting from pedogenesis. The soil was buried at least as early as 7,110 BP. Transport of the materials that now constitute the upper horizons could not have been by marine currents, because the locality is above the point of transgression by Pleistocene seas. Likewise, the flat topography and near absence of rivers in the vicinity suggest that colluvial and alluvial transport were not involved. By process of elimination, the most likely agency was wind. The morphology of the sand grains supports this hypothesis.

If wind were the agency, then conditions must have been more favorable for aeolian transport than at present. Surficial soils today appear very stable, owing both to the near-absence of topographic relief and to the dense cover of herbs and low shrubs that bind the soil and deflect the wind.

Other studies have shown that conditions may indeed have been more favorable for aeolian transport at the time of burial. Full Wisconsin glaciation occurred roughly 20,000 BP, and sea level was 120 m below present sea level (Gascoyne et al., 1979). Water tables were much depressed, causing lakes to be dry (Watts, 1971). There was a steady rapid rise in sea level from 14,000 to 7,000 BP (Milliman and Emery, 1968), corresponding with a world-wide warming trend (Broecker et al., 1960). Thereafter, sea level rose more slowly to its present level (Scholl et al., 1969) and briefly to 1.7 m above present levels about 5,000 BP, causing wave-cut scarps in the Silver Bluff shoreline near the present coast (Murali, 1976).

Pollen profiles from central peninsular Florida, and north to southern Georgia, showed that the predominant vegetation was xerophytic oak, perhaps with large patches of bluestem prairie, from 8,500 to 5,000 BP (Watts, 1971). An abundance of *Ambrosia* and *Artemisia* pollen reflected the dry soil conditions linked to depressed sea levels. More recent studies by Delcourt and Delcourt, (1978) from southeastern Alabama confirmed Watts' results. The modern pine-dominated vegetation did not become predominant until 5,000 BP when present sea levels were attained.

This evidence suggests that conditions were much drier and the vegetation more sparse than at present at the time when soil burial occurred at sites 1 and 2. As a result, the hypothesis of aeolian transport is supported, but the source of the materials is as yet unidentified. The lack of topographic relief precludes the identity of an obvious origin.

Cameron and Mory (1976) made a stratigraphic study of Bradwell Bay. They reported a deep sandy stratum that resulted from the erosion of Wicomico shoreline feature, presumably by wave action. Peat covered part of this stratum, and these peats, in turn, were covered in places by windblown sands from the same Wicomico feature. If Cameron and Mory (1976) are correct, the Wicomico shoreline feature has been eroding slowly by both aeolian and marine transport until virtually nothing was left of it several millenia ago. Perhaps strong winds associated with the recent Silver Bluff transgression resulted in the ultimate leveling of this feature. Because the Wicomico shoreline feature extended through our study sites, it could have provided the sands that buried the original soils in the general region during the Holocene.

The discrepancy of 2,830 yrs between the 2 C-14 dates is bothersome, because both wood fragments came from the same stratum. The abundance of wood suggests that this stratum, when it constituted the surficial horizon, may have been an organic soil, such as occurs in Bradwell Bay today (Hebb and Clewell, 1976; Cameron and Mory, 1976). This took centuries or millenia to develop. After burial, the layer became compacted to its present thickness, bringing together woods of different ages, thus explaining the discrepancy in age. Another explanation for the discrepancy is that the burial of the previous soil took place gradually, allowing younger trees to become rooted at progressively higher elevations than those that they replaced. Preservation of wood and other larger fragments continued as long as water saturated soils maintained anaerobic conditions.

Conclusions—There is good evidence that the Ab horizons at the 30 m elevation location represent soils buried by aeolian transport about 4,280-7,110 BP. This hypothesis may be extended to the other study locations with the possible exception of the one at 37 m where depositional evidences are not convincing.

The Bradwell Bay region holds much promise for paleoecologists interested in studying late Pleistocene environments and in assessing the effects of changing sea levels on near-coastal environments.

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FIRST RECORD OF THE FISH *CUBICEPS BAXTERI* (STROMATEOIDEI, NOMEIDAE) FROM THE WESTERN NORTH ATLANTIC—*Rudolf G. Arndt*, Faculty of Natural Sciences and Mathematics, Stockton State College, Pomona, New Jersey 08240

Abstract: *An exceptionally large specimen of this open ocean genus extends the range of the species some 5400 km from off the coast of western Africa to New Jersey in the western North Atlantic. The specimen is described and figured, and meristics and morphometrics agree well with large individuals from near Japan.*

A fish found dead on a beach in Margate City, Atlantic County, New Jersey on 19 January 1975 is identified as *Cubiceps baxteri. Cubiceps* is a poorly-known open ocean genus containing 7 species and is found worldwide in temperate and tropical oceans (Butler, 1979). According to Butler (1979), *C. baxteri* is known from much of the Pacific, from the Indian Ocean off southern Africa, and from both sides of the South Atlantic. It has been recorded in the North Atlantic only from off western Africa, at about 23°N and 20°W (Haedrich, 1972; Butler, 1979). The new specimen thus represents a range extension of some 5400 km, into the western North Atlantic. Its large size of 795 mm SL is also notable. Fewer than a dozen individuals of similar size have been noted of all *Cubiceps* species worldwide, and only Abe (1955) reported on *C. baxteri* as large as the specimen reported herein.

Except for some damage to the back of the head and to the thoracic area, the specimen was found in good condition. After preservation, counts and measurements were made following Hubbs and Lagler (1958). Radiographs supplemented examination of the fish. Nomenclature herein follows Butler (1979), who recently revised the genus. The specimen and related documentation have been deposited in the U.S. National Museum of Natural History (USNM 220911).

Meristics of the fish (Fig. 1) generally agree with Abe (1955) for 5 large specimens (825-1000 mm SL) taken near Japan and with Butler (1979) for 19 smaller specimens (78.7-418.0 mm SL) from the eastern and western Pacific and the South Atlantic. Differences noted are given later. Meristics: D XI, I 20 (all branched); A III, 20 (all branched); P_1 i, 21 (the first of the 21 segmented only, the rest branched); P_2 I, 5 (all branched); upper principal caudal rays, 9 (uppermost not branched), lower, 8 (lowermost not branched); vertebrae 12 + 19 = 31; lateral line scales at least 61 (damage prevents total count); scales above lateral line at origin of second dorsal, 6½; scales below lateral line at origin of second dorsal, 26; scales below lateral line above anal fin origin, 20½.

Morphometrics fall within the ranges given by Abe (1955) in 9 (indicated by an asterisk) of 13 cases where comparisons can be made and 4 (indicated by a double asterisk) are almost within range, as follows (linear measurements in mm, thousandths of SL in parentheses): weight, 6.84 kg; total length, 970; fork length, 845; maximum body depth, 220 (276**); maximum body width, 114 (143*); caudal peduncle least depth, 65 (81**); caudal peduncle width, 121 (152); predorsal distance, 277 (348); preanal distance, 471 (592); head length, 219 (275*); snout length, 73 (91*); horizontal orbit width, 47 (59*); maximum orbit width, 51 (64); least fleshy interorbital width, 76 (95*); upper jaw length, 53 (66*); lower jaw length, 49 (61); width of gape, 41 (51). Fin lengths: pectoral, 292 (367); pelvic, 98 (123); dorsal, 422 (530); first dorsal, 178 (223); second dorsal, 247 (310); anal, 230 (289); caudal, 220 (276). Longest fin spines/rays and number: dorsal spine (broken), 77 (4th) (96**); dorsal ray, 66 (2nd) (83*); pectoral ray, 278 (7th) (349**); pelvic ray, 90 (2nd) (113*); anal ray, 63 (2nd) (79*). There is less agreement with morphometrics of smaller specimens (Butler, 1979), but this is not unexpected as allometric growth is pronounced in *Cubiceps* (Haedrich, 1967; Butler, 1979).

Other characteristics agree closely with the detailed description of Abe (1955), but only those important in species identification are mentioned here. Eye very large. Pectoral fin much longer than head, its insertion about 3.5 cm in advance of dorsal. Posterior end of upper jaw far in advance of anterior edge of orbit. Body and fins of preserved fish dark purplish, except for lighter brown pectorals and several lighter brown areas on body. Teeth present on jaws, vomer, palatines, and glossohyal. Jaw teeth close-set, fine, conical, and recurved, about 1.5 mm long in upper jaw and slightly shorter in lower. Teeth arranged in single row over most of both jaws, except for most distal portions where absent and front of jaws where the row is either not straight or more than 1 row is present. Vomerine teeth fine and conical ("bristle-like" of Abe, 1955), about 2 mm long and in 1 row on anterior 1.5 cm of vomer. Palatine teeth fine, about 1.5 mm long, on anterior 2.5 cm of palatines, in single row posteriorly and in 3 or 4 rows anteriorly. Glossohyal

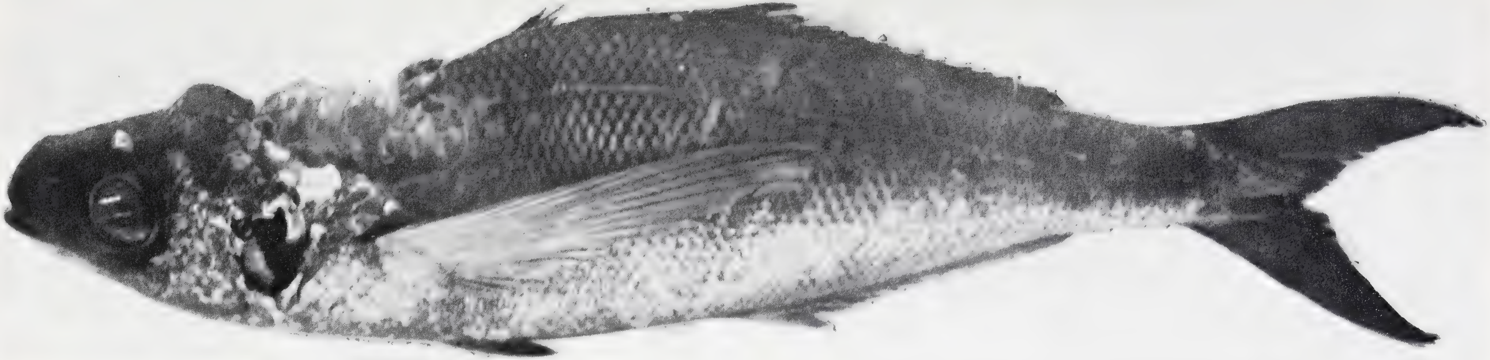

FIG. 1. *Cubiceps baxteri*, USNM 220911; 795 mm SL, New Jersey.

teeth bristle-like, 1.5 mm high, and present in 1 row along midline of posterior half of tongue.

Differences noted are as follows. Total gill raker count on each first arch is 11 + 1 + 20 = 32 (anterior-most ray on each lower arch rudimentary). This is slightly higher than the average of 10.6 + 1 + 18.4 (range 10 + 1 + 18 to 11 + 1 + 19) noted by Abe (1955). Butler (1979) gave a range of 6-10 for each upper arch, and 16-18 for each lower. The specimen has 12 upper procurrent caudal rays, and 11 lower. This is higher than the range for upper and for lower rays of 7 to 10 given by Butler (1979). Finally, the specimen is moderately compressed laterally, whereas Abe (1955) noted that the body is not compressed. However, a photograph in Abe (1955) agrees with the New Jersey specimen. It is not known whether these differences are significant.

According to Butler (1979), the only *Cubiceps* known from the western North Atlantic is *C. pauciradiatus.* It differs strongly from the New Jersey specimen in dentition, fin meristics, and in the presence of a bony keel on the breast. Four of the remaining 6 species recognized and diagnosed by Butler (1979) also differ distinctly from the specimen as follows: *C. gracilis,* known from the northeastern Atlantic and known also to reach a large size, in dentition and vertebrae number; *C. caeruleus,* a southern Pacific and South Atlantic form, in dentition and fin meristics; *C. paradoxus,* known only from a few specimens in the eastern Pacific, in dentition, lateral line scale number, relative eye size, and caudal peduncle proportions; and *C. squamiceps,* known from the western Pacific and the Indian Ocean to southern Africa, in fin meristics, relative length of pectoral fin, dorsal fin origin relative to pectoral fin insertion, and precaudal/caudal vertebrae count.

The remaining 2 species, *C. baxteri* and *C. capensis,* are similar. On the basis of its procurrent ray counts, the New Jersey specimen keys in Butler (1979) to *capensis.* The 1 known specimen of *capensis* as large as the New Jersey fish (Smith, 1849) also has high procurrent ray counts (Butler, 1979). However, according to Butler (1979) the dorsal fin origin of *capensis* is located over the pectoral fin base, while that of *baxteri* is slightly behind the pectoral origin. The specimen matches *baxteri* in this character. Butler (1979) states that the fins of *capensis* are blackish, and a photograph shows this particularly on the pectorals and caudal. The fins of the New Jersey specimen are purplish. Furthermore, the specimen has at least 3 rows of teeth on the anterior portion of the palatines, a character in *Cubiceps* described only for *baxteri* by Abe (1955). Size and distribution data also suggest that the fish is *baxteri:* there is only 1 known specimen of *capensis* as large as the New Jersey fish, and *capensis* in the Atlantic is known only from off southern Africa, whereas large *baxteri* are better known and the species has been reported in the Atlantic much closer to New Jersey. After examining 35 mm slides, radiographs, and other data, J. L. Butler (pers. comm., 1979) has concurred with the identification of this specimen as *C. baxteri.*

Acknowledgments—I thank the following, without whose willing cooperation this paper would not have been possible. C. T. Bilyea, Jr., found the specimen and kindly allowed me to keep it. Charles S. Walkoff, Mainland Medical Center, Pomona, New Jersey and Eugenia B. Boehlke, Academy of Natural Sciences of Philadelphia (ANSP) made the radiographs. Richard L. Haedrich, Department of Biology, Memorial University, Newfoundland and Bruce B. Collette and Robert H. Gibbs, Jr., U.S. National Museum of Natural History, Washington, D.C. pointed out references and answered questions. James E. Boehlke and staff made available the facilities of the Department of Ichthyology and the library of the ANSP and, in particular, he and William F. Smith-Vaniz answered questions and provided valuable discussion. Smith-Vaniz also critically examined the specimen and radiographs. John L. Butler, National Marine Fisheries Service, La Jolla, California examined slides, radiographs, and other data and answered questions. Grace M. Tilger, American Museum of Natural History, New York helped obtain references and Nancy J. Bieber, Stockton State College, typed the manuscript. Franklin F. Snelson, Jr., made helpful comments during manuscript review.

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Biological Sciences

EXTERNAL DEVELOPMENT OF FETAL KEY DEER

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ABSTRACT: *The morphological development of 27 prenatal Key deer* (Odocoileus virginianus clavium) *was described in 10 stages encompassing the late embryo and late fetus. Ages were estimated by interpolations involving length or the cube root of weight and assigned ages of youngest and oldest specimens. The chronological emergence of 37 characteristics was evaluated within* Odocoileus. *Although broad generic similarity was found, 3 discrepancies of 16-32 da were noted between the northern white-tailed deer* (O. v. borealis) *and the Rocky Mountain mule deer* (O. hemionus hemionus). *Comparisons involving* O. v. clavium *revealed inter- and intraspecific discrepancies greater than likely aging error. Based on the relative distribution of these differences, the chronology for* O. v. clavium *seemed no more similar to that of* O. v. borealis *than to that of* O. h. hemionus. *Also, 4 of the characteristics that reportedly developed at similar times in* O. v. borealis *were not synchronous in* O. v. clavium. *A rank order analysis indicated that the relative development of selected integumentary traits was less variable in Key deer than has been reported for the Columbian blacktail* (O. h. columbianus).

THE endangered Key deer inhabits only the lower Florida Keys. Although most noted as the smallest race of white-tailed deer in eastern North America, this insular deer is also morphologically unique from other subspecies (Schwartz, *in* Dickson, 1955; Barbour and Allen, 1922; Klimstra, 1974). Herein, we describe the external development of fetal Key deer and integrate this information with that available for other *Odocoileus.*

Studies concerning the morphological development of fetal deer have been conducted for the northern white-tailed deer, the Rocky Mountain mule deer, and the Columbian black-tailed deer (Cheatum and Morton, 1946; Armstrong, 1950; Short, 1967, 1970; Chattin, 1948; Hudson, 1956; Hudson and Browman, 1959; Ommundsen and Cowan, 1970). The resulting criteria of prenatal development, including growth curves and the chronological emergence of characteristics, have been used to age fetuses and determine breeding dates important in deer management.

External morphological characteristics necessarily reflect the growth and differentiation of various body parts and, for this reason, are perhaps more diagnostic of development than weight and linear measurements. This view has been emphasized for embryonic development (Winters et al., 1942; Hudson and Browman, 1959; Short, 1970) and may also be true for the fetal period. Verme (1963) believed that, within limits, external characteristics develop at a rate largely independent of the fetus's physical vigor. Also, use of grossly discernible features allows identification of comparable developmental stages in the same or different species, regardless of contrast in age, weight, or linear dimension. Armstrong (1950) developed a key based on morphological criteria for determining age of prenatal white-tailed deer in New York. Application of the key to a series of known-age fetuses demonstrated it to be relatively accurate (Palmer, in a note atached to Armstrong, 1950).

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METHODS—Twenty-seven Key deer fetuses were obtained from road-killed does by personnel of the Cooperative Wildlife Research Laboratory (CWRL), Southern Illinois University at Carbondale. Most specimens were preserved in 10 % formalin, but a few were placed in Bouin's solution or frozen. Frozen specimens were later fixed in formalin before examination. Represented were 10 females, 15 males, and 2 unsexable embryos; there were 15 singletons and 12 twins. In the terminology of Winters et al. (1942), the specimens spanned a developmental sequence from late embryo to late fetus. Specimens were individually examined and grouped into 10 stages based on overall similarity of external characteristics. In all instances, morphological similarity resulted in members of a twin pair being grouped together. Stages of development were then described by evaluating all specimens in each group for developmental features in 13 broad morphological categories. Although this artificial system segmented a continuous process, it facilitated description and comparision and therefore was considered justifiable. Crown-rump length of embryos and forehead-rump length of fetuses were measured as described by Armstrong (1950). Although calipers were used for crown-rump length, accuracy was questionable due to indefinite reference points and specimen fragility. Body weight was determined after excess preservative had drained from the specimen. Embryos were weighed to the nearest 0.01 g on an analytic balance; fetuses were weighed to the nearest gram on a torsion balance.

None of the Key deer specimens were of known age, but considering the uniqueness and scarcity of the material, we believed that even approximate ages might be useful. It was evident that embryos in Stages I and II had not been implanted long, and that fetuses in Stage X were near term. Cheatum and Morton (1942) reported that embryonic white-tailed deer did not attach to the uterus until after 30 da. Based on descriptions of white-tailed deer (Armstrong, 1950) and mule deer (Hudson and Browman, 1959), the Stage I and Stage II Key deer were assigned an average age of 37 da. Exposed incisiform teeth, complete hair covering on the tarsal gland, and open eyes suggested an average age of about 190 da for the neonate-like specimens in Stage X (Short, 1967; Armstrong, 1950). Because the average Key deer gestation has been reported as 204 da (Hardin, 1974), the 190 da estimate compared favorably with our subjective evaluation of development.

Average ages assigned to the youngest and oldest specimens were believed accurate within plus or minus 5 and 10 da, respectively. Within this range of error, it seemed possible to estimate ages of the remaining fetuses by interpolation from some linear function of age. Armstrong's data (1950) for 26 white-tailed deer fetuses aged according to the growth curve of Cheatum and Morton (1946) revealed that both length and the cube root of weight were nearly linear functions of age from 37 to 192 da ($r = 0.99$ in both cases). Identical correlations were obtained from Hudson's data (1956) for 5 known-age mule deer fetuses. Consequently, equations predicting age were calculated for Key deer based on the assigned average ages of Stage I-II and Stage X specimens, and their corresponding mean lengths or the cube roots of their respective mean weights.

Results and Discussion—The equations used to predict the ages of individual Key deer were

$$\text{Age} = 28.3 + 14.8\ \text{Wt}^{1/3}$$

and

$$\text{Age} = 30.2 + 0.454\ \text{Length}$$

where age was in days, weight in grams, and length in millimeters. Although length was reportedly less influenced by maternal nutrition than weight (Verme, 1963), and probably a more reliable predictor of age, estimates from the 2 equations were strongly correlated ($r = 0.99$) and similar (mean difference = 6.5 da). Consequently, length- and weight-based ages were reduced to a single estimate (the mean). Two other pairs of equations were calculated to reflect the aforementioned uncertainty regarding average ages assigned to Stage I-II and Stage X specimens. One pair used respective average ages of 32 and 180 da; the other used average ages of 42 and 200 da. Thus, 2 additional ages could be calculated for each fetus by averaging the results from each equation pair. These ages bracketed a range of uncertainty around each estimated age. It should be emphasized that the Key deer ages depended entirely on the accuracy of assigned ages and on the assumption that Key deer lengths and weights were correlated with age as demonstrated for other *Odocoileus;* the aging did not involve a quantitative transference of mathematical relationships from 1 deer to another.

The data of Armstrong (1950) were used to evaluate the potential accuracy of the age estimation technique. Based on means for her youngest and oldest pairs of specimens, equations were calculated predicting age from the cube root of weight and from length. The mean of the weight- and length-based estimates deviated from Armstrong's ages by an average of 4.3 da, indicating that interpolation could provide reasonable estimates. Because the relationship between each predictor and age was slightly sigmoidal, with little or no tendency toward cancellation of errors, the mean estimate underaged by 5-8 da fetuses listed as 55-83 da and overestimated by 6-12 da those identified as 120-160 da. This apparent tendency for systematic error should be considered when evaluating the Key deer ages; however, part of the discrepancy may have resulted from error in the aging of Armstrong's specimens. Palmer's data (note attached to Armstrong, 1950) suggest the possibility that Armstrong's key underages fetuses that are 120-160 da of age. Based on Armstrong's data, length provided more accurate estimates (average deviation = 3.6 da) than weight (average deviation = 5.2 da).

An indication of accuracy for the Key deer ages is given by extrapolating the weight-based equation to the average neonatal weight of 1540 g (Hardin, 1974). The resulting age of 199 da compares favorably with a 204-da gestation reported by Hardin (1974). The distribution of estimated ages by length and weight (Fig. 1) reveals that weight contributed most to within-group variability after Stage V. Thus, ages of a few atypically heavy fetuses may be overestimated (e.g., the 131-da specimen in Stage VI). Age estimates based on "size" discriminated almost completely between the morphological stages. Despite the overlapping age estimates between Stage VIII and Stage IX, specimens in these groups were different developmentally. Ages estimated for members of twin pairs differed by 1-6 da (mean = 3.3 da).

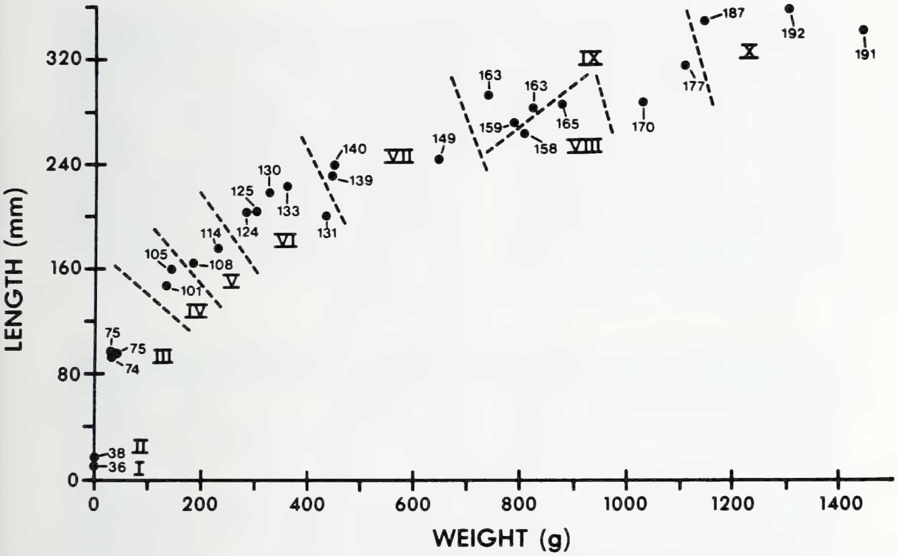

Fig. 1. Distribution of 27 prenatal Key deer according to weight, length, morphological stage (Roman numerals), and estimated age in days.

Specimens in each stage were examined regarding development within the following categories: overall configuration, head and face, vibrissae, mouth and teeth, nose, eyes, ears, antler primordia, genitalia and teats, legs and hooves, leg glands, head pigmentation and body pigmentation and hair pattern. Table 1 was compiled to compare the developmental pattern of *O. v. clavium* with that of *O. v. borealis* and *O. h. hemionus* (Armstrong, 1950; Hudson, 1956; Hudson and Browman, 1959; Short, 1967, 1970) and to allow an overview of development within the genus *Odocoileus*. Consequently, characteristics are limited to those common among 2 or more deer. Omissions for *O. v. clavium* resulted from a gap in specimen distribution (Fig. 1); though the appropriate characteristics were present in Stage III fetuses, degree of development indicated that character emergence occurred much earlier. A complete description for each of the 10 stages can be found in Jacobson (1976). Although visualization of all characteristics is not possible, the distinctive appearance of each stage (except Stage II) is documented in Figures 2 and 3. In Table 1, 2 types of ages are associated with each stage: an

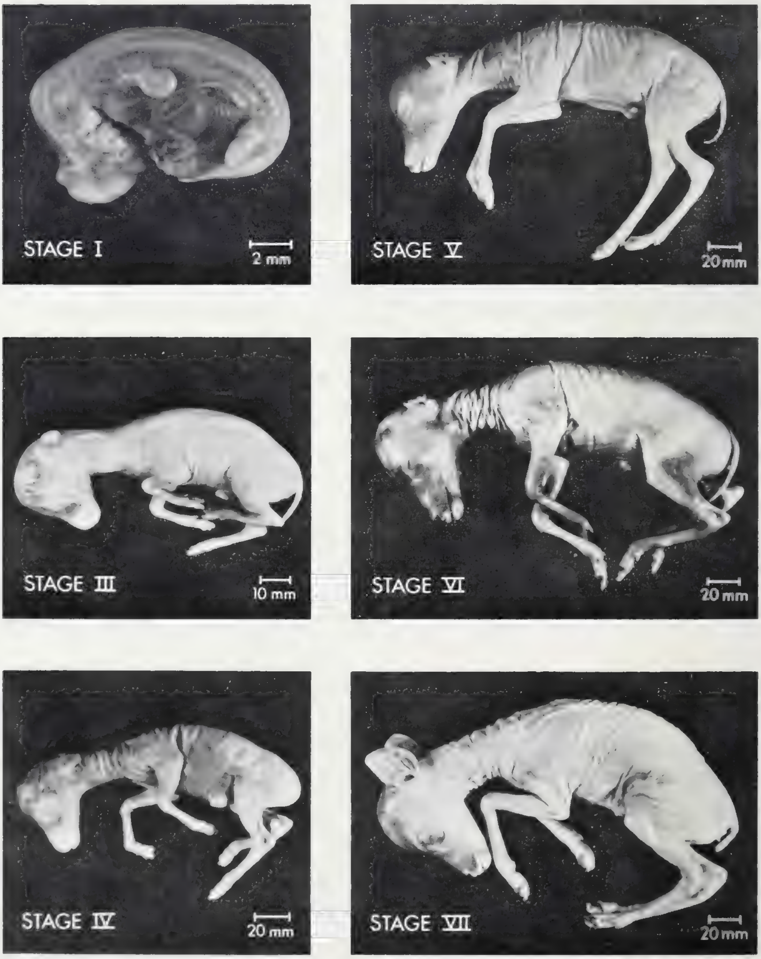

Fig. 2. External appearance of prenatal Key deer, Stages I, III-VII.

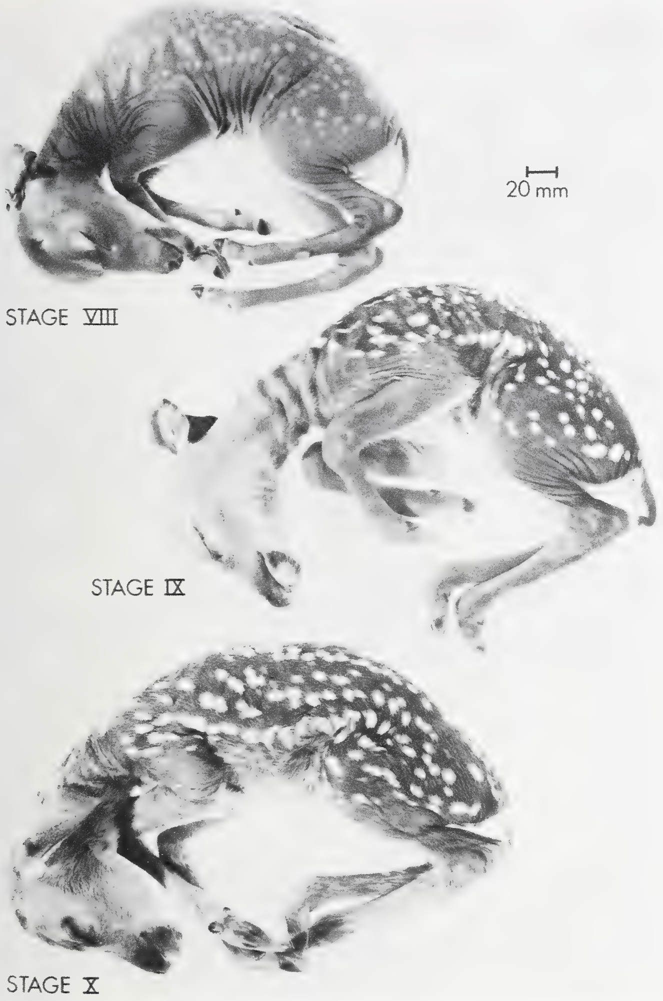

Fig. 3. External appearance of prenatal Key deer, Stages VIII-X.

estimated age representing a "best estimate", and a parenthetical range of uncertainty about that estimate. For stages with more than 1 specimen, the span of each type includes all fetuses within the group.

Several problems associated with this tabulation need emphasis. First, it was necessary to judge the comparability of descriptions. Thus, "eyelashes are grown" (Armstrong, 1950) was equated with "eyelashes well developed" (Hudson and Browman, 1959), and, based on locations, the emerging facial "hair" described by Hudson and Browman (1959) were assumed to be vibrissae. Additionally, the ages cited in Table 1 are not necessarily com-

TABLE 1. Chronology of external fetal development of the Key deer (*O. v. clavium*), the northern white-tailed deer (*O. v. borealis*), and the Rocky Mountain mule deer (*O. h. hemionus*). Each entry for *O. v. clavium* includes the morphological stage (Roman numerals), the span of estimated ages for specimens in that group, and a parenthetical range of uncertainty about that span.

Characteristic	Fetal Age (days)		
	O. v. clavium	*O. v. borealis*	*O. h. hemionus*
1. Iris pigmentation visible	I: 36 (31-41)		34^a 35- 39^b
2. Mouth open, eyelids absent, no vibrissae follicles	II: 38 (33-43)	37- 40^c	
3. Pinnae form triangular projections	II: 38 (33-43)		38^a 30- 39^b
4. Digits discernible (*O. v. clavium*) or differentiated	II: 38 (33-43)	41- 44^c	40- 49^b 45^a
5. Follicles of facial vibrissae visible		41- 44^c 65^d	40- 49^b 45^a
6. Triangular pinnae folded laterally		50- 59^b	40- 49^b 45^a
7. Eyelids developed, mouth closed		53- 60^c	50- 57^a 50- 59^b
8. Coronal and sagittal sutures evident		53- 60^c	57- 61^a 60- 69^b
9. Sex determination by external characteristics is possible		58^d	60- 69^b 60^e
10. Nipples evident		50- 59^b	60- 69^b 61^a
11. Preorbital fold present	III: 74-75 (68-82)	66- 75^c 80- 89^b	60- 69^b

12. Pinnae positioned over occiput	III:	74-75 (68-82)	70- 79[b]	80- 89[b] 68[a]
13. Metatarsal gland discernible	III:	74-75 (68-82)	60- 69[b] 91- 95[c]	60- 69[b] 73[a]
14. First pigment visible on nose	III:	74-75 (68-82)	79- 95[d] 76- 85[c]	70- 79[b] 73[a]
15. Antler primordia discernible	III:	74-75 (68-82)	80- 89[b]	70- 79[b] 73- 83[a]
16. Facial vibrissae visible	III:	74-75 (68-82)	86- 90[c] 90- 99[b]	100-109[b] 111[a]
17. Black pigment present on nose	VI:	124-133 (116-141)	86- 90[c]	111-144[a]
18. Brown pigment present on surface of lower lip, black pigment present along edges of eyelids	VI:	124-133 (116-141)	91- 95[c]	
19. Pigmentation of the hoof discernible	IV:	101-105 (94-112)	96-105[c] 125[d]	90- 99[b] 111[a]
20. External nares open	IV:	101-105 (94-112)	106-110[c]	111[a]
21. Antler primordia pigmented	V:	108-114 (101-122)	111-120[c]	100-109[b] 111[a]
22. Eyelashes well developed	VII:	139-149 (130-158)	111-120[c] 130-139[b]	130-139[b] 144[a]
23. Hair present on pinnae	VIII:	158-165 (150-174)		117[a] 120-129[b]
24. Light spots present along the dorsal surface of the back (fawn spots)	VI:	124-133 (116-141)	111-120[c] 145[d]	110-129[b] 111-144[a]
25. Testes descended	IV:	101 (94-108)	115[d]	90- 99[b]
26. Tarsal gland discernible	VI:	124-133 (116-141)	121-132[c]	80- 89[b] 89[a]

27. First hairs emerge on crown of head	VII:	139-149 (130-158)	120-129[b] 121-132[c]	110-119[b] 144[a]
28. First hairs emerge on body	VIII:	158-165 (150-174)	121-132[c] 130-139[d]	110-119[d] 111-144[a]
29. Rump patch more lightly pigmented than surrounding skin	VI:	124-133 (116-141)	121-132[c]	
30. Row of stiff bristles around top of the hoof, hair present on legs, stiff hairs ring the metatarsal gland, hair present on tarsal gland	VIII:	158-165 (150-174)	133-150[c]	137-144[a]
31. Hair pattern established, pigmentation pattern complete	VIII:	158-165 (150-174)	133-150[c] 160-169[d]	130-139[d] 144-174[a]
32. Entire nose pad black	VIII:	158-165 (150-174)	151-180[c]	
33. Metatarsal gland obscured by hair	X:	187-192 (177-202)	151-180[c]	174[a]
34. Pinnae no longer appressed to head	VII:	139-149 (130-158)	160-169[b]	140-149[b] 144-174[a]
35. Incisiform teeth completely exposed	X:	187-192 (177-202)	180-189[b] 181-200[c]	174[a] 180-189[b]
36. Tarsal gland obscured by hair	X:	187-192 (177-202)	181-200[c]	174[a] 180-189[b]
37. Eyes open	X:	187-192 (177-202)	180-189[b]	180-189[b]

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[a] Hudson and Browman, 1959.

[b] Short, 1967. Subspecific designation inferred from collection area.

[c] Armstrong, 1950.

[d] Short, 1970. Subspecific designation inferred from collection area.

[e] Hudson, 1956.

parable. Our data and Armstrong's (1950) represent the age span of the youngest group of similar specimens showing the characteristic. Although Hudson (1956) and Hudson and Browman (1959) described development in terms of stages, each was a single age. Because fetal stages were spaced 10-33 da apart and many characteristics emerged during the transition periods, time spans associated with some traits may be excessive. Short (1967) divided gestation into 10-da intervals and grouped specimens accordingly. Because of a small white-tailed deer sample, this procedure frequently resulted in a group being represented by specimens at an extreme of the age span (e.g., her 50 to 59-da group contained a single 58-da fetus). Finally, we made arbitrary decisions regarding typographical errors and discrepancies. It was assumed that "eyelashes and eyebrows were now present" in the 111-da fetus (Hudson, 1956) rather than "not present" (Hudson and Browman, 1959). We utilized 130-139 da (Short, 1967) as the interval for eyelashes being well developed instead of 125 da (Short, 1970). External sex determination for the white-tailed deer was tabulated at 58 da rather than 50 da (Short, 1970).

Broad temporal similarity was evident between the developmental patterns of *O. v. clavium*, *O. v. borealis*, and *O. h. hemionus* (Table 1). However, there were some instances where more than 10 da separated nonoverlapping estimates. Only 3 discrepancies of this magnitude (Table 1, characteristics #12, #19, and #27) were found in 26 comparisons between estimates for *O. h. hemionus*. To some extent, good correspondence might have been anticipated because Short's ages were assigned from growth curves presented by Hudson and Browman (Short, 1970). In contrast, 12 comparisons involving estimates within *O. v. borealis* produced 4 differences of 20-25 da (characteristics #5, #13, #19, and #24). Such disparity involving distinctive characteristics may suggest geographic developmental differences, wide individual variability, or error in Armstrong's age estimates (Short's fetuses were known age).

Short (1970) noted interspecific differences in the chronology of fetal development between mule deer and northern white-tailed deer. The emergence of body hair and completion of the pigmentation pattern (with hair present over most of the body) occurred substantially later in the white-tailed deer. However, these differences no longer exist when data from other investigators are also included (Table 1, characteristics #28 and #31). Of 30 comparisons between these species, only 3 characteristics (#17, #25, and #26) differed as previously defined. Although the magnitude (16-32 da) of these differences maintains the possibility of interspecific temporal variation, combined ranges for *O. v. borealis* and *O. v. clavium* would eliminate characteristics #17 and #25 as true specific differences with *O. h. hemionus*.

Twenty-eight intraspecific comparisons between *O. v. clavium* and *O. v. borealis* yielded differences for 6 characteristics (#16, #17, #18, #25, #28, and #34). However, temporal differences for characteristics #16, #25, and #34 are reduced to fewer than 10 da by considering the ranges of uncertainty for *O. v. clavium*. Further, an average of 9 da might be subtracted from the ranges to account for possible systematic error in ages of 120-160 da. This procedure reduces the time discrepancy for characteristic #28 to 2 da, but leaves 17- and 12-da differences for #17 and #18 and creates an 11-da difference for #34.

Consideration from another viewpoint also suggests differences between *O. v. clavium* and *O. v. borealis*. From the ages cited in Table 1, it is evident that Armstrong (1950) found an association between characteristics #26, #27, #28, and #29 for *O. v. borealis*. That is, one would expect to find all these traits within a set of similar fetuses (but each fetus may not show all characters). Estimates by Short (1967) support Armstrong's data, especially since the actual ages of fetuses showing characteristics #27 and #28 were 125 and 135 days, respectively (Short, 1967). Three stages of Key deer fetuses would need to be grouped to include all 4 characters; these could hardly be considered similar (Fig. 2, Stage VI and Stage VII; Fig. 3, Stage VIII).

The extent of developmental variability is relevant here. From a rank order analysis of 37 black-tailed deer fetuses, Ommundsen and Cowan (1970) concluded that individuals varied considerably in the relative development of 10 integumentary characteristics (i.e., traits may develop at different rates in different animals). Between-trait Spearman correlations of 0.57 and 0.21 were cited as indicative of this variability. Although this could explain the discordant trait association noted for *O. v. clavium*, we believe Ommundsen and Cowan's analysis involved much finer resolution than depicted in Table 1. Further, application of their analysis to 18 Key deer fetuses indicated less variability for *O. v. clavium* because all Spearman correlations were 0.92-0.99. Like Ommundsen and Cowan, we noted that twins did not always receive identical ranks, but only 1 pair had a member consistently ranked less developed.

Finally, 27 comparisons between *O. h. hemionus* and *O. v. clavium* produced 6 differences (characteristics #16, #23, #26, #28, #30, and #33). Interestingly, only 1 of these (#26) was also an *O. v. borealis/O. h. hemionus* difference, and only 2 (#16 and #28) were *O. v. clavium/O. v. borealis* differences (but information regarding #23 is lacking for *O. v. borealis*). Uncertainty and bias in the *O. v. clavium* age estimates could eliminate 3 of the 6, but discrepancies of 12-18 da would still exist for characteristics #16, #23, and #26.

The authenticity of differences identified from Table 1 must be viewed with reservation. Small sample sizes detract from the reliability of data for the Key deer and Short's known-age white-tailed deer. Further, Armstrong (1950) relied on the growth curve of Cheatum and Morton (1946) to age her white-tailed deer fetuses, and all mule deer were aged either directly or indirectly from the lengths of 5 known-age specimens (Hudson, 1956; Hudson and Browman, 1959; Short, 1967, 1970). Least reliable were the Key deer ages estimated without benefit of known-age fetuses. Although none of the estimates are believed grossly erroneous, ages based on size can be accurate only in a statistical context because size is influenced by such factors as maternal nutrition (Verme, 1963), litter size (Armstrong, 1950; Verme, 1963), fetal sex (Armstrong, 1950; Haugen and Davenport, 1950), genotype (Hunter, 1956), sire size (Joubert and Hammond, 1958), maternal size (Joubert and Hammond, 1958), maternal age (Verme, 1963) and ambient temperature (Yeates, 1958). We consider the magnitude of many identified differences too large to ignore, but the actual existence or extent of these can only be established by future research. In reviewing the chronological discrepancies, we noted that gaps in specimen distribution or differences in degree of character development might have contributed to all differences within the *O. h. hemionus* data and to 2 within the *O. v. borealis* data (characteristics #5 and #19). However, no evidence could be found suggesting that these factors caused any of the differences noted among deer. Perhaps significant is the fact that the chronology hypothesized for *O. v. clavium* seems as different from that of *O. v. borealis* as from that of *O. h. hemionus*.

Biologists wishing to age fetuses are probably inclined to use growth curves because of convenient and continuous application. However, the complementary use of morphological characteristics might reduce aging errors caused by size variability. It is thus unfortunate that most ages listed in Table 1 are derived from growth curves. Conception dates have commonly been determined to establish breeding dates to facilitate setting hunting seasons. Although it is unlikely that the Key deer will ever be hunted, a better understanding of its reproductive biology is needed. Because most known mortality involves automobile collisions (Hardin, 1974), the opportunity exists to examine a number of pregnant females yearly. Application of our age-estimation equations to recovered fetuses could more closely define general and age-specific breeding dates. We caution, however, that our equations should not be used to age prenatal deer smaller than approximately 0.15 g or 12.5 mm. Hardin (1974) noted breeding activity from early September through late February, with peak activity in early October. Calculated conception dates for our fetuses ranged from 5 September to 22 February, but 12 of the 21 pregnancies occurred between 22 September and 15 October.

As a somewhat peripheral observation, the occurrence of 5 same-sexed pairs among the 6 sets of Key deer twins suggests a high frequency (66%) of monozygotic pairs according to Weinberg's differential calculation (Stern, 1960). Although the sample size is unreliably small, this figure is markedly different from an 8% incidence calculated from mule deer data in Robinette and Gashwiler (1950), and a similarly low rate can be inferred for the Illinois white-tailed deer from comments by Roseberry and Klimstra (1970). The probability of 5 or more same-sexed pairs occurring among 6 sets of dizygotic twins is 0.12. In conjunction with a low rate of twinning (Hardin, 1974), a high incidence of monozygotic twins could indicate that Key deer only rarely ovulate more than 1 ovum. Such a phenomenon could be of nutritional or genetic origin.

ACKNOWLEDGMENTS—Specimens for this paper were obtained during 1967 through 1973 when personnel of the CWRL, Southern Illinois University at Carbondale, were studying the Key deer (Klimstra, 1974). Support funds were contributed by the U.S. Department of Interior Bureau of Sport Fisheries and Wildlife (now Fish and Wildlife Service), National Geographic Society, North American Wildlife Foundation, National Wildlife Federation and Southern Illinois University. Fetuses were collected by A. L. Dooley, J. W. Hardin, B. N. Jacobson, W. D. Klimstra, N. J. Silvy, J. C. Watson, Sr. and J. Watson, Jr. This paper includes information from a thesis submitted by the senior author in partial fulfillment of the M.A. degree requirements in Zoology, Southern Illinois University, Carbondale. F. M. Foote, E. C. Galbreath, and J. L. Roseberry contributed useful comments during the preparation of the manuscript.

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X-RAY POWDER DIFFRACTION DATA FOR LITHIOPHILITE—*Frank N. Blanchard* DEPARTMENT OF GEOLOGY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA 32611

ABSTRACT. *Observed and calculated X-ray power diffraction patterns are presented for lithiophilite and these should serve as a better reference for identification than data currently in the literature.*

OBSERVED and calculated X-ray powder diffraction patterns for lithiophilite are offered as a reference for identification. Lithiophilite is the manganese end member of the lithiophilite-triphylite series (Li(Mn, Fe)PO_4) and crystallizes in the orthorhombic space group Pmnb. The sample used to collect the observed pattern came from the Outpost Mine, White Picacho district near Morristown, Arizona. The specimen is moderate orange pink (5 YR 8/4), has a vitreous luster and is very coarsely crystalline and anhedral with visible cleavages. Optical examination (polarizing microscope) of individual grains of the lithiophilite showed the presence of inclusions which proved by X-ray diffraction to be hureaulite ($Mn_5(PO_4)_2[PO_3(OH)]_2 \cdot 4H_2O$). This particular specimen was chosen from among the available samples of lithiophilite-triphylite because it came closest to the ideal end member composition. In spite of the small amount of hureaulite present, it was possible, by comparing the calculated pattern with the observed pattern, to obtain excellent data for lithiophilite.

METHODS—A small sample of the lithiophilite was coarsely crushed and hand picked for purity. The coarsely crushed material was ground to less than 325 mesh and part of this powder was used for chemical analysis and the remainder was used to prepare 3 samples for X-ray analysis. One portion was prepared with collodion and amyl acetate as a smear on a glass slide. A second fraction was mixed with about 20% silicon (NBS SRM-640) prior to being smeared with collodion and amyl acetate on a glass slide, and a third fraction was mixed with 50% synthetic corundum (Al_2O_3,O.3 micron, Linde A) prior to sprinkling onto a glass slide coated with a thin layer of vaseline. Scans were made with a General Electric XRD-5 diffractometer at 0.2° 2θ/min from 10° to 90° 2θ using Cu-radiation and a graphite monochromator. A 3° divergence slit, MR Soller slit and a 0.1° detector slit were used with a take-off angle of 3°. Observed *d*-spacings were corrected using silicon as an internal standard. Corrected *d*-spacings were used with the computer program of Appleman and Evans (1967) which indexed the reflections and yielded a least squares refinement of lattice parameters. A weighting factor of $1/d^2$ was used for each $\underline{d}$-spacing to minimize the relatively larger errors inherently present at lower 2θ angles.

In addition to the observed powder diffraction pattern, a computer-simulated diffractometer chart and calculated $\underline{d}$-spacings and relative intensities were obtained for lithiophilite. This was accomplished using the FORTRAN IV program for calculating X-ray powder diffraction patterns -- version 5 (Clark, Smith, and Johnson, 1973), with crystal structure data from Geller and Durand (1960). The calculated pattern was useful in distinguishing between observed lines of lithiophilite and those of hureaulite, in unequivocally indexing the observed reflections, as an identification standard, for evaluating the quality of published powder patterns, and in evaluating the reliability of the structure determination.

Quantitative analysis for lithium, manganese, iron, phosphorus, calcium, aluminum, sodium, magnesium, and potassium was done by atomic absorption spectrophotometry, and qualitative analysis for elements from aluminum through uranium was done by X-ray fluorescence. X-ray fluorescence was also used to determine the approximate iron:manganese atomic ratio.

RESULTS AND DISCUSSION—Table 1 includes the calculated $\underline{d}$-spacings (indexed) and relative intensities for lithiophilite. The calculated intensities are corrected for flat-plate absorption (diffractometer), and reflections with intensity less than 0.5 have been omitted.

Hubbard, Evans, and Smith (1976) recommend reporting a standard scale factor (γ) with calculated powder diffraction patterns. This practice permits conversion from relative intensity to absolute/relative intensity. They also point out that the scale factor, γ, may be used with appropriate data for corundum to calculate "the reference intensity ratio" $\underline{I}/\underline{I}_c$. $\underline{I}/\underline{I}_c$ is the integrated intensity ratio for the strongest line of a sample to the strongest line of corundum. For lithiophilite, $\gamma = 0.1828 \times 10^3$ and $\underline{I}/\underline{I}_c = 1.34$. The reference intensity ratio was computed using the computed value of γ for lithiophilite and values of γ, linear absorption coefficient, and density for corundum given by Hubbard, et al. (1976).

Table 1 also includes the observed $\underline{d}$-spacings and relative intensities (peak height) for lithiophilite. Refined lattice parameters obtained from these $\underline{d}$-spacings are $a = 6.108$ (±0.001), $b = 10.459$ (±0.002), and $c = 4.732$ (±0.001).

Intensity measurements of the 131 line (the most intense) for lithiophilite and the 113 line (the most intense) for corundum yield values for $\underline{I}/\underline{I}_c$ which average 1.57 (peak height).

Comparison between the observed pattern and the calculated pattern shows excellent correlation indicating that the crystal structure data closely approximates the structural parameters of the real material, and that the observed data should serve as a good identification standard. Comparison between the observed pattern and the data of card #13-336 (data from a powder camera) in the Powder Diffraction File (Selected Powder Diffrac-

TABLE 1. Calculated and observed X-ray powder diffraction data for lithiophilite. Observed intensities are peak heights, while calculated intensities are integrated areas.

Calculated			Observed		
dA	I	hkl	dA	I	hkl
5.2300	25.3	020	5.236	28	020
4.3204	60.9	$01\bar{1}$	4.313	56	011
3.9705	21.1	120	3.957	24	120
3.7448	9.2	$10\bar{1}$	3.739	9	101
3.5257	74.3	$11\bar{1}$			
			3.516	71	111,021
3.5138	16.5	$02\bar{1}$			
3.0500	67.7	200	3.051	89	200,121
3.0448	13.1	$12\bar{1}$			
2.8095	26.1	$03\bar{1}$	2.805	25	031
2.6347	1.8	220	2.633	12	220
2.5518	100.0	$13\bar{1}$	2.548	100	131
2.4917	31.4	$21\bar{1}$	2.492	28	211
2.4035	22.2	140	2.403	27	140
2.3720	0.4	$00\bar{2}$	2.364	2	002
2.3133	12.0	$01\bar{2}$			
			2.305	19	012,221
2.3033	11.0	$22\bar{1}$			
2.2901	14.1	$04\bar{1}$	2.289	24	041
2.1630	8.5	$11\bar{2}$			
2.1602	11.1	$02\bar{2}$	2.161	16	022,112
2.1440	0.4	$14\bar{1}$			
2.0664	5.9	$23\bar{1}$	2.066	5	231
2.0363	5.9	$12\bar{2}$	2.036	7	122
1.9852	2.7	240	1.986	5	240
1.9142	1.3	$05\bar{1}$	1.914	2	051
1.8724	11.7	$20\bar{2}$			
			1.874	9	202,301
1.8689	1.1	$30\bar{1}$			
1.8671	0.6	$13\bar{2}$			
1.8431	4.0	$21\bar{2}$			
1.8398	13.7	$31\bar{1}$	1.842	9	311,212
1.8263	5.9	$15\bar{1}$	1.826	7	151
1.7628	33.4	$22\bar{2}$			
1.7599	6.5	$32\bar{1}$	1.762	29	222,042+
1.7569	9.3	$04\bar{2}$			
1.7433	1.3	060	1.744	7	060
1.6883	15.9	$14\bar{2}$	1.689	13	142
1.6762	18.6	160	1.676	19	160
1.6472	23.1	$33\bar{1}$	1.647	19	331
1.6213	2.6	$25\bar{1}$	1.622	2	251
1.6052	12.9	340	1.606	10	340
1.5636	0.8	$01\bar{3}$	1.566	2	013
1.5272	1.5	$31\bar{2}$			
1.5250	14.8	400			
1.5224	0.8	$24\bar{2}$	1.527	17	400,152+
1.5205	0.4	$34\bar{1}$			
1.5195	5.4	$15\bar{2}$			
1.5146	10.0	$11\bar{3}$			
1.5137	2.2	$02\bar{3}$	1.515	21	260,113+
1.5135	14.1	260			
1.4691	4.5	$12\bar{3}$	1.470	3	123
1.4640	0.7	420			
			1.464	2	033,420
1.4401	0.8	$03\bar{3}$			
1.4380	3.2	$41\bar{1}$	1.440	4	411
1.4253	7.6	$07\bar{1}$	1.422	9	071
1.4116	0.9	$33\bar{2}$			
1.4047	1.9	$06\bar{2}$			
			1.403	4	133,062+
1.4016	3.6	$13\bar{3}$			
1.3952	0.8	$25\bar{2}$			
1.3937	1.4	$35\bar{1}$	1.396	2	351,252+
1.3879	0.6	$17\bar{1}$			
1.3689	2.8	$16\bar{2}$	1.370	2	162
1.3559	12.0	$22\bar{3}$			
1.3532	1.5	$04\bar{3}$	1.356	7	223,043
1.3403	3.5	$43\bar{1}$	1.343	2	431
1.3294	2.4	$34\bar{2}$	1.331	2	342
1.3235	6.2	360			
			1.323	6	360,143
1.3210	5.3	$14\bar{3}$			
1.3023	2.7	$23\bar{3}$	1.304	2	233
1.2912	9.3	$27\bar{1}$	1.291	8	271
1.2828	1.5	$40\bar{2}$			
1.2748	0.9	$36\bar{1}$			
			1.275	2	412,361
1.2732	2.2	$41\bar{2}$			
1.2693	0.6	$44\bar{1}$	1.273	1	441
1.2643	0.5	$07\bar{2}$			
1.2615	1.3	$05\bar{3}$			
1.2483	0.5	$30\bar{3}$			
1.2458	3.8	$42\bar{2}$			
1.2422	3.2	$35\bar{2}$	1.243 b	3	422,352+
1.2395	2.8	$31\bar{3}$			
1.2142	1.2	$32\bar{3}$	1.214	1	323
1.1881	0.9	520			
1.1860	1.2	$00\bar{4}$			
1.1816	0.7	$50\bar{1}$			
1.1785	1.2	$01\bar{4}$			
1.1752	2.0	$33\bar{3}$			
1.1741	1.6	$51\bar{1}$	1.174 b	3	333,511+
1.1680	1.8	$27\bar{2}$			
1.1671	0.5	$37\bar{1}$			
1.1657	4.1	$25\bar{3}$			
1.1649	2.6	$28\bar{1}$	1.165 b	6	253,281+
1.1566	1.2	$02\bar{4}$			
1.1558	2.2	$36\bar{2}$			
1.1517	2.1	$44\bar{2}$	1.151 b	2	362,442+
1.1503	1.7	$16\bar{3}$			
1.1478	1.7	460			
1.1364	0.8	$12\bar{4}$			
1.1288	1.9	$09\bar{1}$			
1.1265	5.0	$34\bar{3}$	1.125 b	5	343,182+
1.1254	3.1	$18\bar{2}$			
1.1191	6.1	531	1.120	3	531
1.1056	1.1	540			
1.0993	4.7	$21\bar{4}$	1.099	3	214

tion Data For Minerals) indicates that the data presented here will serve as a better identification standard, especially where the diffractometer method is used. Card #13-336 lists 39 lines to $\underline{d}$ = 1.16 while I list 51 lines plus 4 more to $\underline{d}$ = 1.099 (corresponding to 90° 2θ). Indexing on card #13-335 is only to $\underline{d}$ = 1.638 and there are some errors whereas I have indexed all observed lines.

Chemical analysis leads to the formula $Li(Mn_{99.5}Fe_{0.5})PO_4$, excluding the trace amounts of Ca, Na, Mg, and K.

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NOTES ON TERRESTRIAL ACTIVITY OF THE CRAYFISH *PROCAMBARUS ALLENI* (FAXON) IN WEST-CENTRAL FLORIDA

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Abstract: *Terrestrial movements of* Procambarus alleni *leaving and entering a seasonal forest pond in NW Hillsborough Co., Florida were monitored daily for 14 mo. Terrestrial activity occurred almost exclusively during the rainy season from June to October, with large numbers of individuals moving overland during or shortly after periods of heavy rainfall. Migration to and from nearby swamps, river, and terrestrial burrows may explain the overland movements.*

It is well documented that overland movements occur in several crayfish species (Cummins, 1921; Lyle, 1938; Penn, 1943; Hobbs *et al.*, 1967; Hobbs & Peters, 1977). Indeed, Viosca (1939) described "armies of tens of thousands" of *Procambarus clarkii* moving overland. The data reported here are on *Procambarus alleni* movements obtained incidentally during a study of terrestrial activity of striped mud turtles *(Kinosternon baurii)* at a seasonal pond in northwest Hillsborough Co., Florida.

Methods and Materials—Details concerning the habitat and methods employed are reported elsewhere (Wygoda, 1979). Briefly, the pond (2500 m^2 maximum surface area) occupies an 85 m long curved depression with relatively steep sides and expanded, gradually sloping ends. The depression is located 35 m east of the Hillsborough River in an oak-palm forest, portions of which are subject to seasonal flooding. Cypress is dominant in shallow parts of the pond and in nearby seasonal swamps. A 228 m long drift fence encircling the pond and 38 paired pitfall traps (20 1 capacity) served to trap crayfish entering and leaving the pond. Trap contents, rainfall, maximum water depth, and minimum and maximum shaded forest temperatures were monitored daily in the morning hours from 1 March 1975 through 30 April

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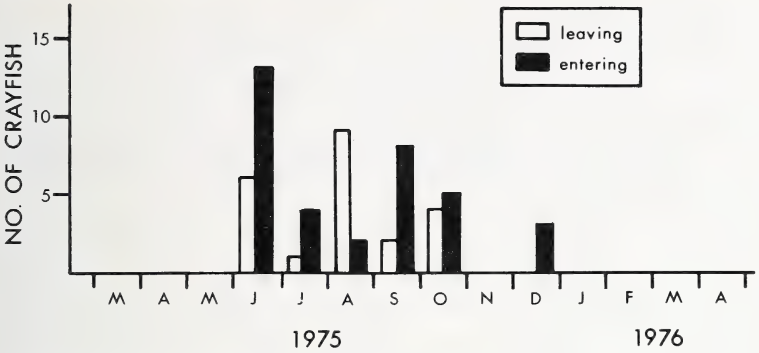

FIG. 1. Monthly summary of *Procambarus alleni* terrestrial captures. Solid bars represent numbers of crayfish entering pond, open bars numbers leaving.

1976 with few exceptions. Crayfish found in traps were placed on the ground 1 m away on the side of the fence opposite that on which they were entrapped. Crayfish also were captured in the pond and in 2 nearby swamps using aquatic funnel traps baited with dead fish. Additional observations were made at the site in May 1977.

RESULTS—No crayfish were caught terrestrially from March through May 1975 (Fig. 1), a period characterized by little rainfall, decreasing pond water depth and increasing temperatures. However, 77 crayfish were caught in aquatic traps in the pond from 5 to 15 April, mostly (71%) in the shallow, expanded ends of the depression. The pond was dry throughout much of May, although the organic muck substrate remained moist in the deepest areas of the depression. No burrows were observed. Terrestrial captures began on 10 June, 2 wk after the advent of the summer rains when the water depth in the pond had reached 11.5 cm. Through 3 December, 22 crayfish left and 35 entered the pond (Fig. 1). Pitfall traps near the expanded ends of the depression accounted for 96% of crayfish leaving and 66% entering. Three crayfish were captured in nearby swamps during intermittent trapping from August to November. Crayfish movement toward the pond was greatest in June, while movement away from it was greatest in August (Fig. 1). The largest daily migration (7 entering) occurred on 13 June and the second largest (4 entering) on 24 June. Net movement was inward during every month except August.

Except in December, all terrestrial captures were made during the rainy season, although only 26% of the incoming and 45% of the outgoing crayfish moved on days during which precipitation occurred. The largest daily movement occurred 2 da after heavy precipitation (36 mm) and the second largest after 8 consecutive days of precipitation totaling 155 mm. Minimum forest temperatures within 24 hr prior to capture ranged from 6.0 to 21.4°C ($\bar{x} \pm$ SD = 18.8 ± 3.0) and maximum from 19.0 to 34.5°C ($\bar{x} \pm$ SD = 26.7 ± 2.4). The highest maximum temperature prior to capture preceeded the largest daily movement and was the highest recorded during the study.

During the period of terrestrial captures, maximum water depth in the pond increased relatively quickly from 11.5 to 143.6 cm and then gradually decreased to 87.6 cm. Both the total number of captures and the average daily capture rate (31 crayfish, 0.42 crayfish/da) during increasing water depth exceeded those during decreasing water depth (26 crayfish, 0.25 crayfish/da). No captures were made as water depth continued decreasing to 0 cm by the end of the study.

Discussion—Although no relationship was found between individual *P. alleni* movements and daily precipitation, these data indicate that terrestrial movements primarily occur during the rainy season and suggest that mass movements are initiated by heavy rainfall. Terrestrial activity also was most intense during the height of the rainy season when water depth was increasing rapidly.

Crayfish did not leave the depression in response to drying of the pond because no terrestrial captures were made during the spring months of 1975 and 1976 as water depth gradually decreased. In May 1977, when the dry depression was revisited, 3 crayfish were found inside a burrow system constructed within a usually submerged cabbage palm log. Although no burrows were observed in the exposed substrate during the study or the May 1977 visit, they probably were present but unnoticed because of plugged entrances and chimneys destroyed by infrequent, light showers (Horton H. Hobbs, Jr., pers. comm.). However, a 1x3 m transect dug to the underlying sand in May 1977 failed to reveal crayfish burrows.

The destination of crayfish leaving the pond can not be determined from these limited data. Aquatic trapping records from the swamps suggest that crayfish seasonally occupy these shallow habitats. The possibility that migration was directed to and from the Hillsborough River also must be considered because *P. alleni* is known to occur there (Horton H. Hobbs, Jr., pers. comm.). A third possibility is that crayfish migrated to and from terrestrial burrows in the surrounding forest as populations of this species are known to do in south Florida (Steve Godley, pers. comm.). None of these explanations, however, are mutually exclusive. Further studies are needed to clarify the role of terrestrial activity in the population ecology of *Procambarus alleni*.

Acknowledgments—I am especially grateful to Dr. Horton H. Hobbs, Jr. for discussing *P. alleni* ecology with me and for reviewing this note and encouraging its publication. I thank Steve Godley and Richard Franz for reviewing an earlier draft of this note, and Jack A. Ehleiter for providing valuable field assistance. Southwest Florida Water Management District generously granted permission to conduct the study on its property. This study was funded in part by the Department of Biology, University of South Florida.

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DISTRIBUTION OF PARASITES IN THE ANIMAL KINGDOM—*David Nicol*

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Abstract: *About 68.0% of all animal phyla have only free-living species, and approximately 11.0% of all animal phyla have only parasitic species.*

Taxonomists who work on the Echinodermata have long boasted that there are no parasitic species in that phylum. However, some phyla with nearly as many or more species (Porifera, Coelenterata, and Bryozoa) also have no species that are parasites.

For this analysis, I have used the following sources for the basic data: Barnes, 1974, Hyman, 1940, and J. A. C. Nicol, 1960. The classification I have used for the animal phyla is that of Blackwelder, 1963, with slight modifications. The list of phyla with their approximate number of species (Table 1) is taken from a previously published paper (D. Nicol, 1979). Whether a particular species is a parasite or free-living is in most instances indisputable; this is certainly true of the endoparasites. However, a few of the ectoparasites may be classified either as parasites or as predators.

The 6 largest animal phyla have both free-living and parasitic species, but this is not unexpected. The Vertebrata have less than 100 species that are parasites, and the Mollusca have few species that are parasites.

The most noteworthy fact is that 25 of the 37 phyla listed in Table 1 have only free-living species. This amounts to 67.6% of all animal phyla. However, 19 of these 25 phyla are small and each has less than 1,000 living species. These 19 small phyla have about 3,000 species. Conversely, 4 of the 37 phyla have only species that are parasites, and they are all small phyla with less than 1,000 species each. The total number of species in these 4 phyla is 950. Twelve phyla have some or all parasitic species, and this comprises 32.4% of all of the animal phyla. Eight, or 21.6% of the animal phyla, have both parasitic and free-living species. As was mentioned before, 6 of these are the largest animal phyla, and the Annelida is a large phylum. The only small phylum that has both parasitic and free-living species is the Myzostomida.

TABLE 1. The extant animal phyla with the number of species in each and those having free-living and/or parasitic species.

Phyla	No. of Species	Free-living	Parasitic
1. Protozoa	35,000	x	x
2. Mesozoa	50		x
3. Monoblastozoa	1	x	
4. Porifera	5,000	x	
5. Coelenterata	10,000	x	
6. Ctenophora	100	x	
7. Platyhelminthes	13,000	x	x
8. Rhynchocoela	750	x	
9. Acanthocephala	600		x
10. Gnathostomulida	90	x	
11. Rotifera	1,500	x	
12. Gastrotricha	350	x	
13. Kinorhyncha	100	x	
14. Priapuloidea	8	x	
15. Nematoda	50,000	x	x
16. Gordiacea	230		x
17. Calyssozoa	60	x	
18. Bryozoa	4,000	x	
19. Phoronida	25	x	
20. Brachiopoda	300	x	
21. Mollusca	58,000	x	x
22. Sipunculoidea	300	x	
23. Echiuroidea	150	x	
24. Myzostomida	150	x	x
25. Annelida	9,300	x	x
26. Tardigrada	350	x	
27. Pentastomida	70		x
28. Onychophora	75	x	
29. Arthropoda	1,000,000	x	x
30. Chaetognatha	75	x	
31. Pogonophora	100	x	
32. Echinodermata	6,000	x	
33. Pterobranchia	25	x	
34. Enteropneusta	100	x	
35. Tunicata	1,600	x	
36. Cephalochordata	30	x	
37. Vertebrata	41,700	x	x
Total	1,239,219	33	12

Parasitism is a specialized mode of life, and it occurs in relatively few phyla of the animal knigdom. It is also true that few classes of the animal phyla have species that are parasites, as one can see by reviewing Blackwelder's (1963) classes of the animal phyla. In other words, a similar pattern to the distribution of parasites in phyla also occurs in the classes of the phyla. An estimate of the number of species of parasites in the animal kingdom is not feasible at this time because so many of these small animals are still unknown.

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NEW RECORDS OF MARINE FISHES IN THE INDIAN RIVER LAGOON SYSTEM, FLORIDA[1]

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Abstract: *Four fish species,* Ophichthus gomesi, Ophidion marginatum, Echeneis neucratoides, *and* Hypleurocheilus geminatus, *are recorded for the first time from the Indian River lagoon system on the east coast of Florida.*

Gilmore (1977) summarized the occurrence and distribution of fishes inhabiting the Indian River region of east-central Florida, including species known from ocean, lagoon, and associated brackish and fresh water habitats. He reported 275 species from the mesohaline waters of Indian River lagoon system proper (exclusive of ocean inlets and connecting fresh waters). Subsequent additions and/or corrections to the fish fauna of the lagoons have been published by Gilmore, Bullock, and Berry (1978), Hastings (1978), Snelson and Bradley (1978), and Snelson and Williams (in press).

The records reported herein are based on data gathered during an ichthyofaunal survey and fish community study in the northern portion of the Indian River lagoon system in Brevard County, Florida. The study region was mapped and described by Gilmore (1977), Snelson and Bradley (1978), and Snelson and Williams (in press). Abbreviations used herein are SL (standard length), TL (total length), ANSP (Academy of Natural Sciences of Philadelphia), UF (Florida State Museum, University of Florida), and UCF (University of Central Florida).

Ophichthus gomesi (Castelnau)—shrimp eel. Gilmore (1977) did not list this species in his checklist for the Indian River region. Six adult specimens were taken from the Indian River near the town of Frontenac (lat. 28° 28.2'N, long. 80° 45.7'W) between 24 and 31 October 1978. All were taken from samples impinged on cooling-water intake screens at the Florida Power and Light Company electricity generating station. They are deposited as follows: ANSP 143075 (1 spm., 62 cm TL), UF 27505 (3 specimens, 48, 58, and 71 cm TL) and UCF uncataloged (2 specimens, 67 and 73 cm TL).

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[1] Contribution No. 24, Merritt Island Ecosystems Studies.

Ophidion marginatum (DeKay)—striped cusk-eel. This name combination replaces *Rissola marginata* of earlier authors (Cohen and Nielsen, 1978). This species was reported from bottom trawl collections made in the ocean off Cape Canaveral, Florida (Anderson and Gehringer, 1965) but has not been recorded previously from the lagoon system. A specimen 151 mm SL (UF 27504) was collected from the Indian River near the western terminus of Haulover Canal (lat. 28° 43.0′N, long. 80° 46.0′W) on 21 May 1979. It was trawled at night near the channel of the Intracoastal Waterway where the depth was 1.8-2.4 m.

Echeneis neucratoides Zuieuw—whitefin sharksucker. Snelson and Bradley (1978) reported the first record of *Echeneis naucrates* Linnaeus from the Indian River system. That specimen (UF 27509) is an adult 49 cm SL. A second sharksucker (UCF uncataloged), a juvenile 19 cm SL, is tentatively identified as *E. naucrates.* It was collected in a trawl 11 September 1979 in the Indian River near the western terminus of Haulover Canal (lat. 28° 43.0′N, long. 80° 46.5′W). It was not associated with a host.

A sharksucker identified as *E. neucratoides* (UF 27510) was trawled in the southern portion of Mosquito Lagoon (lat. 28° 42.5′N, long. 80° 42.0′W) on 30 October 1978. It is an adult 43 cm SL. It was not associated with a host when collected. This species is generally uncommon and has not been reported previously from the lagoon system.

Echeneis naucrates and *E. neucratoides* are similar in meristic characters and are difficult to distinguish except when specimens of similar size are in hand (Böhlke and Chaplin, 1968). Direct comparison of the 2 large specimens from the lagoons leaves no doubt that both species are represented. The specimen of *E. naucrates* (UF 27509) exhibits the following diagnostic features: 1) body slender, depth 9.9% of SL; 2) white pigment on dorsal and anal fins limited to a narrow fringe on extreme tips of rays and membranes at apex of fins only; 3) white pigment on caudal fin limited to a narrow fringe along the upper border of the upper lobe and at the tip of the lower lobe; 4) caudal fin with a deep, lunate margin, as illustrated by Böhlke and Chaplin (1968: 319). The specimen of *E. neucratoides* (UF 27510) contrasts as follows: 1) body stout, depth 15.1% of SL; 2) white pigment on dorsal and anal fins extensive, covering a broad triangular area in the apical third of the fins and extending rearward along margin of the fins to near their ends; 3) white pigment on caudal fin covering a large triangular area at the apex of the upper and lower lobes, slightly more extensive ventrally than dorsally; 4) posterior margin of caudal fin trilobed, with middle rays produced, almost as long as upper and lower rays, and forming a low rounded lobe somewhat more exaggerated than the specimen illustrated by Böhlke and Chaplin (1968:320). Meristic characters of the 2 specimens are in the broad range of overlap between the species (Böhlke and Chaplin, 1968) and are not diagnostic.

Hypleurochilus geminatus (Wood)—crested blenny. Gilmore (1977) listed the crested blenny as "occasional" in the vicinity of ocean inlets in east-central Florida. I report here a specimen (UF 27503) 37.1 mm SL captured in the lagoon system about 76 km from the nearest inlet. It was collected in the Indian River near the town of Frontenac (lat. 28° 29.5′N, long. 80° 45.5′W) on 28 September 1978. It was trawled from the bottom in the dredged Intracoastal Waterway channel immediately east of the Orlando Utilities Commission electricity generating station. The depth was 2.6 m.

All 4 species reported herein have distributions that extend both north and south of the Brevard County portion of the Indian River lagoons. In view of the extensive fish sampling conducted in this region in recent years (Gilmore, 1977; Schooley, 1977; Snelson, 1980; others unpublished), it appears that these 4 species are truly rare in the lagoon waters. Snelson and Williams (in press) have discussed possible explanations for the rarity or absence of certain elasmobranch fishes in the northern portions of the lagoon system. The same explanations apply to the teleosts reported herein.

ACKNOWLEDGMENTS—The shrimp eels, striped cusk-eel, and crested blenny were collected by Applied Biology Inc. personnel during their studies of the Indian River. I am grateful to Mark J. Provancha, John H. Travis, and David J. Herrema for their cooperation and for permission to cite these specimens. Numerous University of Central Florida students and staff have assisted with the ichthyological studies. I thank them all, especially William K. Bradley, Jr. and Timothy J. Mulligan. Dr. James E. Böhlke confirmed identification of the eel, Dr. C. Richard Robins confirmed the cusk-eel, and Dr. Carter R. Gilbert verified the blenny. Partial financial support was provided by a contract with the John F. Kennedy Space Center, National Aeronautics and Space Administration (NAS 10-8986) and by UCF Division of Sponsored Research in-house grant awards.

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Florida Sci. 44(1):61-63. 1981.

FURTHER INVESTIGATIONS ON THE OCCURRENCE OF STYLOSANTHES HAMATA (L.) TAUB. IN FLORIDA—*John B. Brolmann*,

University of Florida, ARC Fort Pierce, Florida 33450[1]

Abstract: *A new ecotype of* Stylosanthes hamata *(L.) Taub. was collected north of the Jupiter inlet. This* S. hamata *differed from previous collected ones in having smaller leaves, a more prostrate growth and stronger lateral branching. It could be grown at a wider range of pH's than most other ecotypes.*

A Previous Paper (Brolmann, 1979) reported the range of *Stylosanthes hamata* in south Florida to be from Jupiter inlet to Florida Keys. Since then several ecotypes of *S. hamata* were found north of the Jupiter inlet to about 3 km south of Stuart. This extends the northern limits of this species in Florida by about 30 km. Most ecotypes found north of the Jupiter inlet were similar to those described earlier. One ecotype, however, differed greatly from those previously reported. This *S. hamata* has been found in 2 locations (1) near Hobe Sound, southeast of intersection U.S. Highway 1 and Florida State

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[1] Florida Agricultural Experiment Station Journal Series No. 1872.

Route 708; (2) on the west side of U.S. 1, 0.5 km south of County Road C-722 (a small patch of a few plants).

This newly-found S. *hamata* is prostrate (2-3 cm tall) with strong lateral branching (to 60 cm long). It is easily differentiated from other S. *hamata* ecotypes because it forms a dense mat of vegetation. The leaves are one-half the size of the more common S. *hamata* types. Leaflets are dark green and lanceolate to 12 mm long and 2 mm broad with 1-5 short hairs on the edge of leaflets. Stipules are bidentate with 1-3 long hairs on both teeth. Sheath of the stipules are 5-6 mm long, and teeth are 5 mm long. Flower measurements are: Standard 3-3.5 mm long and 4-4.5 mm broad, wings 2-2.5 mm long, keel 2 mm long. Seed size and shape are similar to other ecotypes. Seed of the upper articulation of the loment is dark brown and glabrous. Seed of the lower articulation is pilose. Chromosome number is 2N = 20. This ecotype flowers almost year round but heaviest bloom occurs during the summer and early fall months. It produces an abundance of seed. Progeny studies indicate that this S. *hamata* is self-pollinated.

In tests at the Agricultural Research Center of Fort Pierce this ecotype behaves as an annual and does not have much cold tolerance. It is well adapted to soil types other than the calcareous soils on which it was found and can be grown at various pH levels from 4.5-8.0. This S. *hamata* yielded more forage near the end of its growing season (late October) than most of the other *Stylosanthes* species tested, including other S. *hamata* indigenous to South Florida. The rapid growth of this ecotype during the summer months and its ability to grow on different soil types could make this S. *hamata* a useful forage legume for south Florida pastures.

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Brolmann, John B. 1979. Distribution and significance of *Stylosanthes hamata* (L.) Taub. in south Florida. Florida Sci. 42:63-64.

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Biological Sciences

EFFECTS OF THE EXOTIC PLANTS MELALEUCA QUINQUENERVIA AND CASUARINA EQUISETIFOLIA ON SMALL MAMMAL POPULATIONS IN THE EASTERN FLORIDA EVERGLADES

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ABSTRACT: *The exotic plants* Casuarina equisetifolia *and* Melaleuca quinquenervia *have become established in South Florida. The effect of these plants on the local fauna is not known. We studied the effects of* Melaleuca *and* Casuarina *on the 3 sympatric rodents (*Peromyscus gossypinus, Sigmodon hispidus *and* Oryzomys palustris*) found in the Everglades. Three study areas with different types of habitats were established. The habitats trapped included* Casuarina *heads, cocoplum heads, combination* Casuarina *and cocoplum heads,* Melaleuca *heads and mixed* Melaleuca-*graminoid heads. Sherman live traps baited with oats were set in 2 successive nights during each rotation.* Casuarina *habitats supported fewer rodents than either cocoplum or* Melaleuca *habitats. Rodents captured on the combination* Casuarina-*cocoplum head showed a clear preference for the cocoplum half.* Peromyscus *were found primarily in the interior of the mature* Melaleuca *head, while* Oryzomys *occurred primarily and* Sigmodon *exclusively in mixed* Melaleuca-*graminoid habitat. Frequency of recaptures of* Peromyscus *and* Sigmodon *indicated that each was resident in its preferred habitat.*

EXOTIC plants are invading southern Florida at a rapid rate. These plants were originally introduced for a variety of purposes: for food, to dry out interior wetlands, to provide wind-breaks for farmland, to consolidate canal banks, and as ornamentals. Most of these plants have not become established and pose no threat to natural plant communities in South Florida. A few of these plants, however, have escaped cultivation and are spreading into native plant communities (Lahart, 1977; Austin, 1978).

Australian pine (*Casuarina equisetifolia*) and paperbark tree (*Melaleuca quinquenervia*) are 2 exotic trees that are established in South Florida. They are displacing native plants resulting in a decrease in plant species richness in the habitats they are invading (Austin, 1978). The effects of these plants on the local fauna is unknown, but it is generally felt that few animals are associated with these exotic plant communities (Lahart, 1977; Austin, 1978).

Small mammals are an important link in the food chain between plants and other animals, especially raptorial birds, snakes, and medium-size mammals. If native animals are being displaced, this could have a serious effect on local food webs. We investigated the effects of *Melaleuca* and *Casuarina* on the 3 sympatric rodents *(Peromyscus gossypinus, Sigmodon hispidus* and *Oryzomys palustris)* found in the Everglades.

We asked the following questions to determine the effects of *Melaleuca* and *Casuarina* on small mammals in the Everglades: 1) What small mammals live in these habitats? 2) What are the relative densities of rodents and are they permanent residents or transients? and 3) Does recruitment (breeding) occur in these habitats?

DESCRIPTION OF STUDY AREAS—We set up 3 study areas during this investigation (Fig. 1). The Chekika study area is at the south-eastern edge of the Davis Everglades region (Davis, 1943). The study area is dominated by well-defined, elevated, roughly circular tree islands separated by a sawgrass (*Cladium jamaicense*)—mixed graminoid prairie. During the wet season (June-October) the prairie is flooded and the tree islands provide the only dry ground. During the dry season (November-May) the prairie becomes dry and dusty.

Three types of tree islands are found at the Chekika study area. Most abundant are tropical hardwood hammocks. These hammocks are characterized by high plant species richness and complex habitat structure (Smith and Vrieze, 1979). At least some portion of the hammock remains dry during the wet season allowing for the colonization of tropical hardwood trees. Low ground along the perimeter of the hammocks is dominated by cocoplum *(Chrysobalanus icaco)*. Smaller tree islands which become at least partially flooded during the wet season consist almost exclusively of cocoplum. They are termed cocoplum heads. The third type of tree island in this area is termed *Casuarina* head. These may or may not become partially flooded. *Casuarina* heads have virtually no understory vegetation.

The Tamiami study area is located 27 km west of Miami and south of the Tamiami Trail (U.S. 41). This area shows all phases of *Melaleuca* invasion into wet prairies. There is a 2 ha, *Melaleuca* head estimated to be 30 yr old, which contains tall mature trees in its center. There is almost no understory. The periphery of this head is a dense ring of saplings approximately 6-7 yr old. Surrounding this head is a partially drained sawgrass-mixed graminoid prairie dotted with clumps of *Melaleuca*. These areas are dry from January to June. The large head floods faster and takes longer to dry down (by 2-3 wk) than the surrounding area.

The South study area is close to and southeast of the intersection of U.S. 1 and the Card South Road (State Highway 905). Here, there is an extensive expanse of mature *Casuarina*. Like the smaller *Casuarina* heads at the Chekika site, there is no understory. Within 200 m south of this *Casuarina*

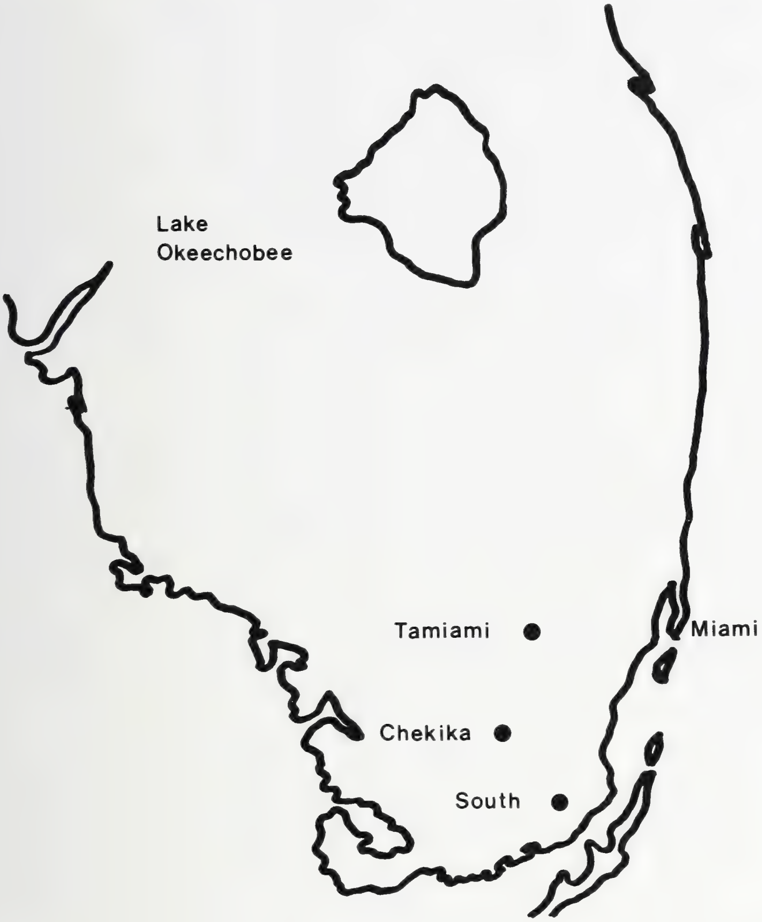

FIG. 1. Location of study areas Eastern Everglades, Florida.

forest are hammock tree islands with high species richness of trees each skirted by single species fringes of cocoplum. The hydrology of this area is similar to that of the other 2 study areas.

MATERIALS AND METHODS—Sherman Live Traps baited with oats were set on 2 successive nights during each trapping rotation. Traps were set at dusk and picked up at dawn. Inter-trap distance at all sites was between 3-4 m. Each animal caught was weighed, sexed, classified as adult or juvenile, identified by toe clipping, and examined for reproductive condition. Traps, with 2 exceptions, were set in grids. The grids were either rectangular or conformed to the shape of the tree island. One exception was the large *Melaleuca* head. Here 2 trap lines were set perpendicular to each other. The other exception was a trap line set in the prairie near the *Casuarina* head. These general techniques have proven effective in sampling Everglades rodents (Smith and Vrieze, 1979).

Chekika study area: Three tree islands were trapped at the Chekika site. They were 0.06 ha *Casuarina* head, a 0.03 ha cocoplum head, and a 0.14 ha tree island that was half *Casuarina* and half cocoplum (termed combination head). These grids conformed to the shape of the island. The cocoplum head was trapped in an attempt to separate the effects of exotic plants from that of a monoculture. These data can be compared with those of Smith and Vrieze (1979) who trapped species-rich hammock islands in the same area. The combination head was trapped to determine habitat preference within a limited spatial dimension. Seventy traps were set each night on the *Casuarina* head, 40 were set on the cocoplum head, and 80 on the combination head. The *Casuarina* and cocoplum heads were trapped for 10 rotations between April 1976 and April 1977. The combination head was trapped for 6 rotations between September 1976 and April 1977.

Tamiami study area: We trapped 2 heads at the Tamiami study area: a 2 ha mature *Melaleuca* head and a 0.03 ha mixed *Melaeuca*—graminoid head. A grid of 40 traps was set in the mixed habitat. Because of the large area of the mature head, trap lines were used to census this habitat. Two lines of 40 traps perpendicular to each other were established. The Tamiami site was trapped for 7 rotations from May 1976 to April 1977.

South study area: Two grids of 40 traps were set at the South study area in December 1976 and April 1977. One grid was in a solid forest of *Casuarina*, the other in a plant species-rich hammock with a high proportion of cocoplum.

RESULTS—In all habitats sampled, the occupancy patterns of Everglades rodents were nonrandom. At the Chekika study area *Casuarina* habitats were essentially depauperate compared to cocoplum habitats (Tables 1 and 2). On the *Casuarina* head low relative densities of *Peromyscus* were found only in April and May 1976, while on the nearby cocoplum head, high relative densities were found in the dry season of each year (Table 1). No

TABLE 1. Number of animals caught per trap night on the *Casuarina* head and cocoplum head from April 1976 to April 1977. No *Sigmodon* or *Oryzomys* were caught in *Casuarina.*

	Casuarina		*Cocoplum*	
	Peromyscus	*Peromyscus*	*Sigmodon*	*Oryzomys*
April	0.2	0	0	0
Early May	0.15	0.9	0	0
Late May	0.05	1.4	0	0.1
June	0	0	0	0.1
July	0	0	0	0.6
August	0	0	0	0
October	0	0	0	0
December	0	0	0	0.5
January	0	0.6	0.1	0
April	0	0.7	0.1	0.1

TABLE 2. Number of animals caught per trap night on the 2 halves of the combination head (September, 1976—April, 1977).

Habitat	Species	Sept	Oct	Nov	Dec	Feb	Apr
Cocoplum	*Peromyscus*	0.12	0.18	0.22	0.26	0.30	0.33
	Sigmodon	0.08	0.16	0.08	0.18	0.02	0
Casuarina	*Peromyscus*	0	0	0	0	0	0.01
	Sigmodon	0	0.02	0	0.02	0	0

Peromyscus were caught on the cocoplum head in the wet season when it was almost completely flooded. No *Sigmodon* or *Oryzomys* were trapped on the *Casuarina* head, while they were found sporadically on the cocoplum head. In January and April 1977, traps set in the prairie near the *Casuarina* head yielded *Peromyscus* and *Oryzomys*, but no animals were trapped on the *Casuarina* head.

On the combination head both *Peromyscus* and *Sigmodon* were trapped almost exclusively in the cocoplum half of the island compared to the *Casuarina* half (Table 2). Further, when animals were released in the cocoplum half, they immediately sought cover there. Animals released in the *Casuarina* half did not seek cover until they had wandered into the cocoplum half.

The same pattern of habitat occupancy emerges from trapping at the South study area (Table 3). Here, despite the fact that the *Casuarina* forest was only 200 m from the hammock island, almost all captures of *Peromyscus* and all captures of *Sigmodon* were on the hammock.

Not only were few individuals of each species of rodent captured in these *Casuarina* habitats, but periods of residency was also significantly shorter than in the natural habitats. Of all captures in *Casuarina*, only 1 individual (a *Peromyscus* in April-May 1976) was ever recaptured there. By comparison, many individuals of each species on natural habitat trapping grids appeared to be permanent residents (Smith and Vrieze, 1979).

TABLE 3. Number of animals caught per trap night on the South study site. Total captures in 2 nights divided by 80 traps.

	Hammock Island		*Casuarina*	
	Dec 1976	Apr 1977	Dec 1976	Apr 1977
Peromyscus	0.19	0.34	0	0.04
Sigmodon	0.11	0	0	0

TABLE 4. Number of animals caught per trap night on the *Melaleuca* head and the *Melaleuca* mixed head (May, 1976—April, 1977). No *Sigmodon* were caught in *Melaleuca* head.

Habitat		(Early) May	(Late) May	July	Aug	Nov	Jun	Apr
Melaleuca head	*Peromyscus*	0.05	0.07	0.06	0.01	0.06	0.03	0.11
	Oryzomys	0.01	0.01	0	0	0	0	0
Melaleuca mixed head	*Peromyscus*	0	0	0	0.01	0.01	0.01	0
	Sigmodon	0.03	0.09	0.10	0.03	0.08	0	0.05
	Oryzomys	0.01	0	0	0.01	0.06	0.04	0.01

In contrast to the depauperate fauna in *Casuarina* habitats, each rodent species was common in *Melaleuca* habitats (Table 4). *Peromyscus* were found primarily in the interior mature stands of *Melaleuca* where they were at highest density throughout the dry season. *Oryzomys* occurred primarily and *Sigmodon* exclusively in mixed *Melaleuca*-graminoid habitat. Frequency of recaptures of *Peromyscus* and *Sigmodon* indicated that each species was resident in its preferred habitat. *Oryzomys* appeared to be transients on the study area.

Data on reproduction and recruitment are too few to present a quantitative analysis of their phenology. One trend, however, was clear: no reproductive animals were ever caught in *Casuarina* habitat. Reproductive animals and juveniles occurred in native and *Melaleuca* habitats.

DISCUSSION—The importance and role of rodent populations in the Everglades ecosystem has recently been stressed by Smith and Vrieze (1979). Working on a constellation of 6 native hardwood hammocks in the Chekika study area, they determined that densities of *Peromyscus gossypinus*, *Sigmodon hispidus* and *Oryzomys palustris* were significantly higher than those reported for other populations of each species throughout its respective geographic range. Because rodents are a source of food to species in all vertebrate classes, these high densities should not be overlooked. The present study expands upon the work of Smith and Vrieze to include cocoplum heads, a hammock island in a different drainage system, and most importantly, the exotic habitats of *Casuarina* and *Melaleuca*.

Iterating the data on relative density, reproduction and permanency within habitats, it is clear there are distinct differences in occupancy among habitat types by Everglades rodents. Using all criteria, *Casuarina* may be considered a poor habitat for rodents. In contrast, *Melaleuca* may contain each of the co-dominant Everglades rodents. The distinction between *Casuarina* and *Melaleuca* is important because it points out that not all exotic habitats are equal. Each habitat must be evaluated separately for its suitability for animal populations.

The cues used by rodents to assess habitats were not critically tested in this study, but appears that low species richness of plants per se does not determine rodent distribution and abundance. Three of the habitats trapped were monocultures (cocoplum, *Casuarina* and *Melaleuca)*, yet there were distinct differences among habitat types in their usage by rodents. Further, it does not appear that foliage structure is a proximate cue; despite their differences in rodent occupancy patterns, *Casuarina* and *Melaleuca* are more similar structurally than they are to cocoplum or hammock habitats.

Exotic plant communities can no longer be intuitively classified as biological deserts. There are differences in their ability to support native wildlife. However, this should not be interpreted to mean that *Melaleuca* is a good habitat for wildlife. Low numbers of rodents were caught in the *Melaleuca* head throughout the duration of the study (e.g., only 17 *Peromyscus*) compared with an average of over 100 per ha of *Peromyscus* found by Smith and Vrieze (1979) in native hammock communities.

There are no data relating to the use of *Melaleuca* as a direct food source by rodents. Further, it is unknown if this habitat is accessible to higher members of the food web that would normally utilize Everglades rodents. These aspects of the dynamics of *Melaleuca*-rodent interactions should be determined to assess the ability of *Melaleuca* to support native wildlife.

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Environmental Sciences

INFRARED ABSORPTION STUDY OF HUMIC SUBSTANCES FROM LAKE APOPKA SEDIMENT, PLANKTON AND THE SURROUNDING DRAINAGE BASIN

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Abstract: *Infrared absorption spectra were run on humic substances from Lake Apopka sediment samples and compared with spectra from citrus and muck farm humic substances from sediment in the surrounding drainage basin, and also with spectra from autochthonous plankton humic substances. The 1540 cm^{-1} and 1650 cm^{-1} peaks in the plankton and lake sediment samples, in addition to other spectra similarities, indicate that plankton is the probable precursor of lake sediment humic substances. The absorption bands at 1650 cm^{-1} and 1540 cm^{-1} are thought to be due to peptide bonds in protein, with amide I absorption occurring at 1650 cm^{-1} and amide II absorption at 1540 cm^{-1}. The spectra from the muck farm soil and citrus soil differ to a greater extent from the spectrum of the lake sediment than do the plankton spectra.*

Lake sediments contain many kinds of organic compounds, but the main components of most lake sediments are the humic substances. In fact, humic substances are major components of the organic matter from marine and freshwater sediments and from soils. Some aquatic sediments may contain 70% of their organic carbon in the humic and fulvic acid fraction (Nissenbaum and Kaplan, 1972). These humic substances are formed during the decomposition of biogenic materials, and are biochemically resistant to further decomposition (Otsuki and Hanya, 1967). Humic substances in lake sediment can be both autochthonous, derived from the lake biota, and allochthonous, derived from the biota and soil of the drainage area. There are 2 principal hypotheses as to the formation of humic acid. One states that humic acid is derived from lignin; the other indicates that other substances such as carbohydrates are largely involved in the formation of humic acid (Otsuki and Hanya, 1967). According to Kononova (1966), the steps which constitute the process of formation of humic substances in soils are twofold: the decomposition of tissue components to simpler, chemically individual substances; and the synthesis of high molecular weight substances, humic substances, from these simpler substances. If this process also occurs in recent lake sediments the changes should be reflected in the infrared spectra of the sources of the humic substances prior to and during decomposition.

Bottom sediments of lakes and rivers may be regarded as soils which have developed under water-logged conditions. There are, however, a lack of suitable methods for classifying aquatic sediments according to their physical, chemical and biochemical characteristics, which are of importance as these characteristics can affect the limnology of the entire aquatic system.

In this study an attempt was made to use infrared methods as a limnological tool to evaluate characteristics of humic substances from a lake's bottom sediments and sediment from the surrounding watershed.

Description of lake and watershed—Lake Apopka is located 24 km west of Orlando. This large (12,140 ha) and shallow lake (2 m) once was nationally known for its clear waters and good bass fishing. In recent decades, however, Lake Apopka has become hypereutrophic and is now populated by blue-green algae, floating mats of water hyacinths, shad, and brown bullheads. Both the cause and cure of Lake Apopka's water quality problems are controversial. Studies indicate that a major source of nutrients entering the lake was agricultural runoff from muck farms located on the north shore of the lake. Other sources of fertilization to the lake have been a citrus process plant discharge, a treated municipal sewage treatment plant effluent located in Winter Garden, Gourd Neck Spring, subsurface leaching, citrus soil runoff, rainfall, and recycled bottom deposits (Brezonik et al., 1978). The lake receives water from rainfall, runoff, seepage, and Gourd Neck Spring. The long hydraulic retention time for the lake (6.3 yr) indicates the lake is essentially a closed system.

Unconsolidated silt, muck, and peat cover over 90% of the lake bottom. This muck and decaying organic matter is very flocculent and ranges in depth from 0.3 to 12.3 m throughout the lake (Sheffield and Kuhrt, 1969). Table 1 summarizes results of several chemical and biological parameters that are useful in determining the water quality and trophic state of the lake (Brezonik et al., 1978). These data indicate extremely poor water quality and when they are applied to various trophic state indices (TSI), such as Carlson's (1977) TSI and Brezonik and Shannon's (1971) TSI, they indicate the lake is highly eutrophic.

Most of the soils surrounding Lake Apopka are well-drained sands suited for citrus production. The muck farm area located primarily on the north shore of the lake is below lake level and was once lake bottom. This muck farm area comprises 7,284 ha of nutrient-rich organic soil devoted entirely to row (vegetable) cropping agriculture. Because the farms are lower than the lake level, the nutrient-rich irrigation water must be periodically pumped

Table 1. Summary of 1977 mean annual levels of trophic parameters for Lake Apopka (from Brezonik et al., 1978).

Parameter	Inorg N(mg/L)	TN (mg/L)	TP (mg/L)	Ortho-PO_4-P (mg/L)	SD (m)	CHl a (mg/m$_3$)	Net Primary Production (g C/m^3-day)
Value	0.095	3.51	0.222	0.047	0.29	33	0.14

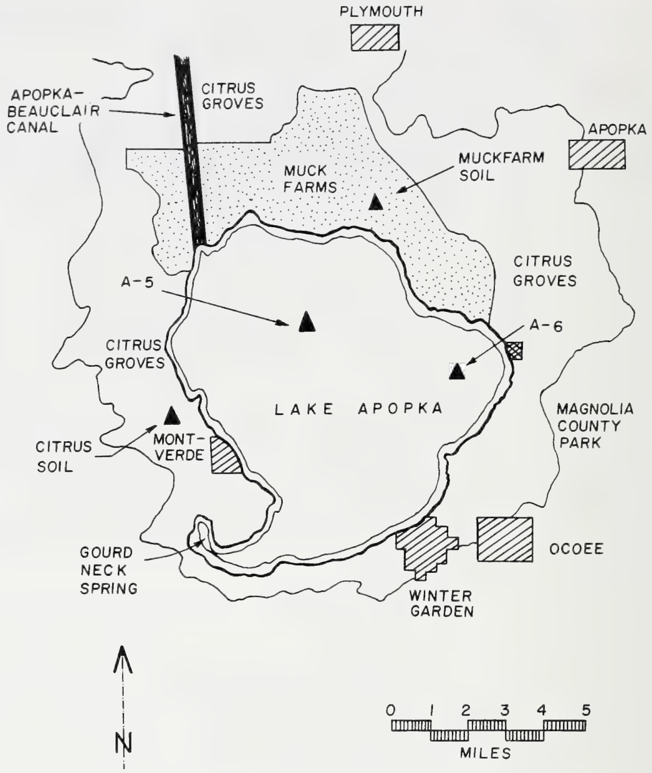

FIG. 1. Lake Apopka sampling stations and surrounding area.

into the lake. Much of the blame for the lake's rapid deterioration has been attributed to the pumpage (ECFRPC, 1973). Effective methods have presently been implemented to control nutrient inputs from the muck farms.

METHODS—Few studies of infrared spectra of humic substances from recent lake sediments have been made (Ishiwatari et al., 1965, 1966; Ishiwatari, 1967; and Otsuki and Hanya, 1967). In this study the infrared spectra of Lake Apopka sediment humic substances at various lake locations were compared with the infrared humic substance spectras of possible precursors of it, such as lake plankton, muck farm soil and citrus soil. Sample collection locations and land use types are in Fig. 1.

Samples were prepared similar to procedures outlined by Ishiwatari (1967) and Nissenbaum and Kaplan (1972). The sediment and plankton samples were dried at 105 °C in an oven for 24 hr and then ground in a motar and pestle and stored in a desiccator. The humic substances were extracted in a 0.5N NaOH solution on a shaker table for 24 hr. The humic substances were centrifuged at 9000 rpm for 20 min and the supernatant was recovered and filtered through a 0.42 u millipore filter. The pH of the filtered solution was then adjusted to 7. The humic substances were put in semipermeable

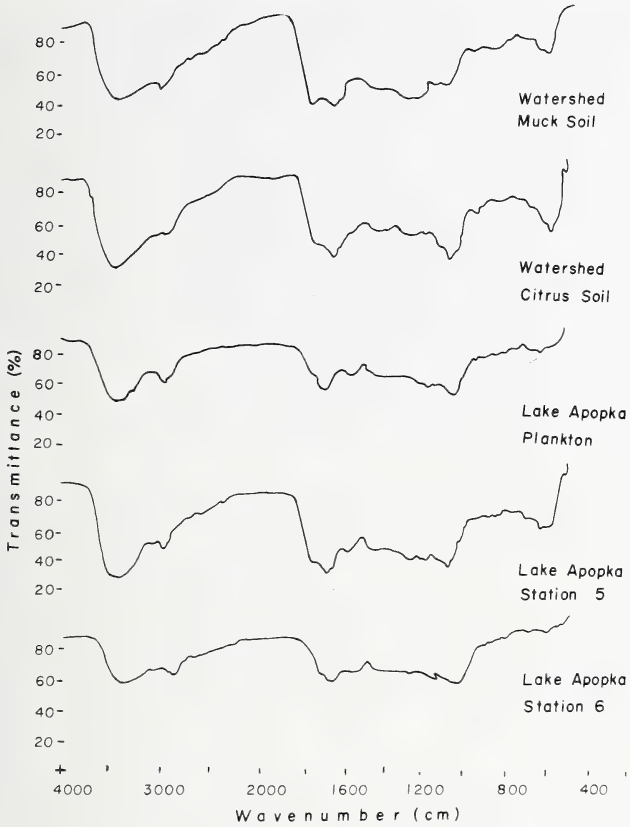

FIG. 2. Infrared spectra of humic substances from Lake Apopka bottom sediment, watershed sediment and plankton.

cellulose dialysis tubes (6.4 mm dia. pore size), and allowed to dialyze by alternating external solutions of 0.1 N NCl and distilled water for approximately 10 hr in a multiple dialyzer. This was done to purify and demineralize the sample, although part of the low molecular weight fulvic acid fraction passes through the membrane and is lost. The samples were freeze dried and then ground in a Wig-L-Bug amalgamator. The infrared spectra of humic substances and dried plankton extract were recorded on a Perkin Elmer model 127 Infrared Spectrophotometer by the common KBr disk method (ration of 300 mg KBr to 1mg sample). The infrared spectra was determined on the entire humic substance fraction and not the individual humic acid or fulvic acid fractions. Kjeldahl nitrogen determinations of the dried sediment samples were made using the standard procedure on a micro-kjeldahl apparatus.

RESULTS AND DISCUSSION—The infrared spectra are in Fig. 2. The infrared spectra of humic substances from sediment at 2 stations in the lake differ only slightly from the plankton infrared spectrum, the main difference being that the relative intensities of the 1540 and 1650 cm^{-1} peaks are slightly greater in the plankton extract. The spectra of the citrus soil and muck farm soil differ to a greater extend from each other and from the spectra of the lake sediment and plankton samples. It has been suggested by Beer et al., (1959) that protein as a class can be distinguished with certainty from other biological compounds such as carbohydrates, lipids, or nucleic acids solely on their infrared spectra, because the variability of protein spectra is very small. The absorption bands at 1650 and 1540 cm^{-1} are thought to be due to peptide bonds in protein, with amide I absorption occurring at 1650 cm^{-1} and amide II absorption at 1540 cm^{-1} (Ishiwatari, 1967). Amide I absorption is based on the carbonyl group of a peptide bond, and amide II absorption is based on the carbon-nitrogen bond. Of significance, then, is the absence or reduced intensity of the 1540 and 1650 cm^{-1} peaks in the citrus and muck farm sediment samples.

Otsuki and Hanya (1967) suggest that humic substances in recent lake sediments are supplied from dead organisms by the action of microbes and physical-chemical alteration, but retain to a large extent the composition of the original organisms and undergo no large qualitative molecular change during decomposition. Nissenbaum and Kaplan (1972) have proven that plankton was the precursor for certain marine humic acids. In this study, the 1540 cm^{-1} and 1650 cm^{-1} peaks (protein) in both the plankton and lake sediment samples, in addition to similarities in the entire spectra of these samples, indicate that plankton is the probable precursor of the lake sediment humic substances (Fig. 2). Considering a closed lake such as Apopka, in which the high plankton production represents the major source of organic matter to the bottom, this conclusion is logical . The Kjeldahl nitrogen content of each sediment sample was determined and is in Table 2. The higher TKN content in the lake sediment and plankton samples seems to correspond to the higher protein content, as indicated by the high 1540 and 1650 cm^{-1} peaks in these samples.

The infrared absorption peaks observed from the samples are in Table 3. Major differences between the samples are that the citrus sediment has a much stronger 1040 cm^{-1} peak than the lake sediment and muck farm humic substances, indicating the strong presence of ether groups in polysac-

TABLE 2. Kjeldahl nitrogen content and percent volatile solids of sediment samples.

Station	TKN (mg N/g dry sediment)	VS (%)
Muck Farm	6.9	42.4
Citrus	1.0	2.2
A-5	23.7	59.4
A-6	21.9	66.3

TABLE 3. Interpretation of infrared absorption peaks observed in infrared spectras from Lake Apopka sediment, plankton, and drainage basin sediment.

Wave Number (cm^{-1})	Assignment
3400	OH groups, intermolecular bonding of hydroxy groups.
2910	Related to methylene groups, CH_2.
2850	Methyl groups, CH_3.
2325	If present, possible nitrile group, $C \equiv N$.
1720	Arises from stretching vibration of carbonyl groups of saturated aliphatic acids, ketones, or esters. Possibly from carboxylic acids in lipids.
1650	Due to amide I absorption of protein or protein-like substances, based on carbonyl group of peptide bond.
1630	$C = O$ group of acid, ketone, or quinone.
1540	Due to amide II absorption of protein, based on carbon-nitrogen bond.
1450	Methyl and methylene group, C-H bending vibration.
1380	Methyl group, C-H bending vibration.
1220	Contribution from C-O, ether or ester. Amide III is probable.
1150	Carbon-oxygen bond.
1040	C-O stretching vibration of ether groups in polysaccharides.
920	$=$C-H out of plane bend, alkenes ($RCH = CH_2$).

charides. The citrus humic substance also exhibited a 925 cm^{-1} peak, which was absent in the lake sediment and muck farm samples, indicating the presence of alkenes. The muck farm humic substance had a sharper 1725 cm^{-1} peak than the other samples, indicating a strong contribution from aliphatic acids, ketones, esters, or possibly from carboxylic acids in lipids.

This study was concerned with the characterization of sediment humic substances from Lake Apopka and its watershed. Much work remains in characterization of humic substances from other terrestrial and aquatic systems.

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POLYGONELLA POLYGAMA (POLYGONACEAE) IN FLORIDA—

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Abstract: Polygonella polygama *is considered to consist of 3 varieties of which 2, var.* polygama *and var.* brachystachya, *are found in Florida. A key to the 3 varieties and synonymy is provided.* Polygonella polygama *var.* brachystachya *(Meisn.)* comb. et stat. nov. *is proposed.*

The North American genus *Polygonella* ranges from southeastern Canada west to eastern Minnesota and south to New Mexico and Florida. Its greatest species diversity is in the southeastern states and principally in Florida.

Small (1933) recognized 5 species in the genus (*P. polygama, P. macrophylla, P. brachystachya, P. croomii*, and *P. americana*) and placed several other species in the closely related *Thysanella, Dentoceras*, and *Delopyrum*.

Fernald (1937) in considering *P. polygama* and *P. brachystachya*, recognized them as distinct species. The former occurs in the eastern coastal plain extending to Florida and west into Texas, while the later is restricted to Florida. Fernald further considered *P. croomii* to be a narrow-leaved variant of *P. polygama* and reduced it to a variety under the latter species. Similarly he considered *P. brachystachya* to be composed of 2 entities. The peninsular Florida taxon was considered a broad-leaved variant of the typical narrow-leaved *P. brachystachya* found in south Florida. He gave varietal status to the broad-leaved variant (*P. brachystachya* var. *laminigera*).

Horton (1963) revised *Polygonella* and reduced Small's genera *Dentoceras* and *Delopyrum* to synonymy under *Polygonella*. *Thysanella* was reduced to subgeneric status, also under *Polygonella*. Considering *P. polygama* to be single highly variable species, he reduced *P. brachystachya* (including var. *laminigera*) and *P. croomii* (*P. polygama* var. *croomii*) to synonymy under that species. In all, 9 species of *Polygonella* were recognized by Horton.

In examining Horton's inclusive *P. polygama* for the forthcoming *Flora of Peninsular Florida*, it became apparent that the situation had been oversimplified and that *P. polygama sensu lato* encompassed 3 morphologically and more or less geographically discrete entities, 2 of which occur in Florida. These entities are: (1) typical broad-leaved var. *polygama* ranging from southwestern Virginia south along the fall line throughout the Carolinas and Georgia to central Florida, southern Mississippi and Alabama to eastern Texas; (2) the northern narrow-leaved var. *croomii* ranging from southeastern North Carolina into South Carolina; and (3) the southern and south central Florida narrow-leaved var. *brachystachya*. Small (1933) states that var. *croomii* ranges south to North Florida, but no specimens have been seen to verify this. A key to distinguish among these varieties and the nomenclature of each is presented here.

KEY TO THE VARIETIES OF *Polygonella polygama*

1. Leaves (2-) 3-6 mm wide . . . . 1. var. *polygama*
1. Leaves 0.5-1.0 mm wide.
    2. Ocreola tips acuminate and prolonged, 1.0-1.5 mm long; plants of North and South Carolina . . . . 2. var. *croomii*
    2. Ocreola tips acute and not prolonged, up to 0.5 mm long; plants of southern and south-central Florida . . . . 3. var. *brachystachya*

1. POLYGONELLA POLYGAMA (Vent.) Engelm. & Gray var. POLYGAMA
Polygonum polygamum Vent., Hort. Cels. 65. 1800.
Polygonella parvifolia Michx., Fl. Bor.-Amer. 2:240. 1803.
Stopinaca parvifolia (Mishx.) Raf., Fl. Tellur. 3:11. 1837.
Polygonella polygama (Vent.) Engelm. & Gray, Boston J. Nat. Hist. 5:231. 1845.
Polygonella subnervis Meisn. in DC., Prodr. 14:80. 1856.
Polygonella brachystachya var. *laminigera* Fern., Rhodora. 39:406. 1937.

2. POLYGONELLA POLYGAMA var. CROOMII (Chapm.) Fern., Rhodora. 39:406. 1937.
Polygonella croomii Chapm., Fl. S. U.S. 387. 1860.

3. POLYGONELLA POLYGAMA var. BRACHYSTACHYA (Meisn.) *comb. et stat. nov.*
Basionym: *Polygonella brachystachya* Meisn. in DC., Prodr. 14:80. 1856.

In Florida, 2 taxa are found, var. *polygama* and var. *brachystachya*. The former, a broad-leaved taxon, occurs in west Florida, peninsular Florida south to Charlotte County and is disjunct in the southeastern coastal counties of Palm Beach and Broward counties, while the narrow-leaved var. *brachystachya* occurs in southern and south-central Florida (Fig. 1). It is not known whether the peculiar disjunct distribution for var. *polygama* is real or an artifact of poor collecting. It needs to be investigated further.

Florida populations of the broad-leaved var. *polygama* appear at first to be more robust than those to the north and west, but numerous intergrades occur. It appears that the narrow-leaved taxa, var. *croomii* to the north and var. *brachystachya* to the south, have evolved independently from the wide

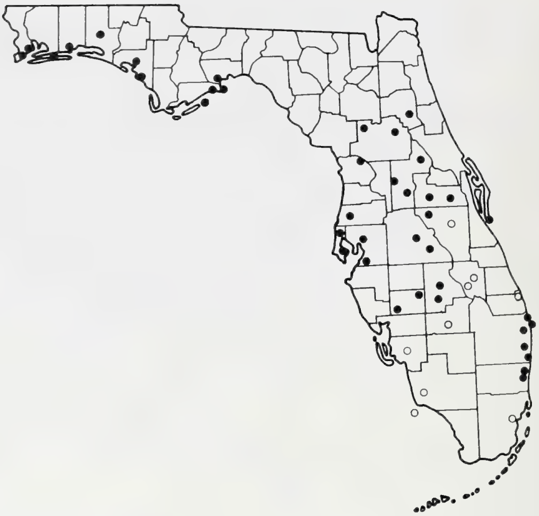

FIG. 1. Distribution of *Polygonella polygama* var. *polygama* (closed circles) and var. *brachystachya* (open circles) in Florida.

ranging var. *polygama* in response to some environmental factor, perhaps moisture availability.

Specimens were examined from the herbaria of the University of Florida, Florida State University, and Florida Atlantic University in addition to those at the University of South Florida. Loan of specimens from FLAS, FSU, and FAU is gratefully acknowledged.

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SEASONAL FOOD RESOURCES AND PREY SELECTION OF THE SOUTHEASTERN BROWN BAT (*MYOTIS AUSTRORIPARIUS*) IN FLORIDA

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Abstract: *Prey availability and changes in food selection by* M. austroriparius *were examined on 3 nights, 1 during the period of lactation in early summer and 2 during the intermittant cold weather in early spring. Analysis was based on 669 whole insects and 93 fecal pellets. Warm temperate zone weather strongly influences insect availability and hence the phenology of this insectivorous bat. On the colder spring night, only Diptera were active, and the bats selected the largest—mosquitoes and crane flies. On the warmer spring and summer nights, flying insects were more diverse and abundant, and the bats selected several kinds with a preference order of Coleoptera, Lepidoptera, and culicid Diptera. Though feeding as generalists on several prey taxa, the bats appeared to select prey on the basis of size within taxonomic groups. The long period of ample food supply for warm temperate* M. austroriparius *contrasts with the short growing season for cool temperate* Myotis lucifugus *and with year-round food availability for tropical emballonurids, with distinct implications for timing and duration of bat reproduction in the 3 zones. Seasonal differences in food supply may also influence the size of summer and winter colonies.*

Compared with most Nearctic bats and with continental populations of its own species, the southeastern brown bat *(Myotis austroriparius)* in peninsular Florida has many peculiar features in its life history. We evaluate the relation of food resources to phenological events documented by Rice (1957), as follows. *M. austroriparius* in peninsular Florida forages during winter nights except during and after passage of cold fronts, when the bats temporarily enter torpor. Rather than breeding in autumn and delaying fertilization through hibernation, mating occurs from early spring at the winter roost sites to mid-spring at nursery roosts (mid-February to mid-April). Parturition takes place in late spring (mid-April to mid-May), and young begin flying in early summer (during June). Nursery colonies are large, typically with thousands of bats, whereas winter roosts are occupied by only a few hundred individuals.

Because insect flight activity is related directly to ambient temperature (for example, see Williams, 1939; Taylor, 1963), the temperature fluctuations associated with passage of winter fronts should strongly affect the prey available to insectivorous bats. The insect community active during bat lactation and recruitment must support the year's peak bat population at maximum foraging density. We document the range of resource supply and changes in food selection by *M. austroriparius* at these crucial times of the year.

SEASONS AND SAMPLING DATES—Northern Florida is on the southern edge of the warm temperate zone (Holdridge, 1967; Dohrenwend and Harris, 1975). Consequently the region's climate includes both temperate and subtropical features, with a double rainy-dry cycle superimposed on the 4 temperature-related seasons. Spring and autumn are dry seasons. Summer begins in mid-May and is characterized by southerly winds, rain almost daily, and daily maximum temperatures hot enough to inhibit plant growth (above approximately 33°C, Holdridge, 1967). Winter spans December, January, and February, with subfreezing temperatures occurring on an average of 10 da, and is cold enough to cause typical overwintering modes of life in many species. Passage of Pacific or Arctic fronts produces warm, rainy weather, followed by clear, cold days and nights, on about a biweekly cycle.

By careful selection of sampling dates, we were able to compare the times of interest by studying food and feeding on 3 markedly different nights. On the first 2 nights (17-18 and 23-24 February 1976) we sampled near a winter roost during the transition between winter and spring. These nights were the warm and cold extremes (respectively) of the winter's last frontal weather. Plant phenology during the later night showed that spring was beginning. Bat behavior at this time indicated mating activity (see Results), so these samples represent foraging conditions at both extremes of winter weather and at the beginning of the mating period.

The third sample (30-31 May 1976) was taken near a nursey roost 2 wk after the onset of summer rains. Population samples at the nursery a few days earlier had shown that adult females were lactating and young bats were soon to begin flying.

STUDY AREAS—The winter roost, inhabited by approximately 200 *M. austroriparius*, was located in a closed manhole chimney of a stream culvert in Gainesville, Alachua Co., Florida. Most bats exited from the south entrance of the culvert and flew south to forage over a lake and marsh area approximately 0.5 km away. Smaller numbers of bats leaving to the north foraged over diverse vegetation along the floodplain, including riparian trees, a shrubby oldfield, and a small woodlot of slash pine *(Pinus elliotii)* and laurel oak *(Quercus laurifolia)*.

The nursery colony included 15,000 adult females and young *M. austroriparius* occupying a cave near Ocala, Marion Co., Florida, 68 km S of the winter roost. Previous monitoring indicated the adult population prior to partuition consisted of 5000 females and no males. The surrounding habitat used in foraging was mesic forest (warm temperate moist forest, Holdridge, 1967) dominated by sweetgum *(Liquidamber styraciflua)*, laurel oak, water oak *(Q. nigra)*, and pignut hickory *(Carya glabra)*.

METHODS—Insects were sampled with a Johnson-Taylor suction trap (Johnson and Taylor, 1955; Taylor, 1962; Burkard Scientific Ltd., Herts, England) with a 30.5 cm intake fan, powered by a quiet Honda E300 generator. The fan turned at 1245 rpm, sampling flying insects in 1090 m^3 of air per hour. The trap mouth was placed at the minimum height of bat feeding passes, 1 m above the ground. Johnson-Taylor traps employ no attractant and simply suck in insects that fly near the trap. Consequently our samples were not biased by inclusion of the differentially phototactic groups of insects attracted to conventional light traps. Less marked biases of suction traps, as functions of wind speed and insect momentum (size), are correctable with the manufacturer's conversion table. Because our samples were taken on windless nights and all captured insects were small, no correction of the data was necessary. At the winter site the insect trap was placed in the floodplain foraging area 35 m north of the culvert exit. At the nursery site the trap was located at a bat foraging area in the forest 65 m north of the cave entrance.

Insect collections were automatically segregated into 45-min samples by the trap. Trapping began with the appearance of the first bat and continued through completion of the 45-min period in which bat activity ceased. The samples were removed from the trap, placed in individual containers, and dried in an oven at 70°C for 24 hr. Dried insects in each 45-min sample were identified to morph (species or phenotypic variant of a species), weighed on an analytical balance accurate to 0.1 mg, and measured to 0.1 mm using a microscope equipped with an ocular micrometer. Average weights of the smallest insects were derived by weighing several insects of that morph and dividing by the number weighed. Weights and numbers for morph, family, and order were tabulated for each subsample and for the entire nightly sample. Morphs were considered to be species for diversity calculations (H′, Shannon and Weaver, 1949). A total of 669 insects was taken in the 3 samples.

Fecal material was collected by placing dropcloths below roost entrances. A total of 93 droppings was collected and analyzed. After spreading the contents of each fecal pellet in water about a petri dish, fragments of insect exoskeleton were identified and sorted by orders. By equating the surface area covered with volume, and determining percent volume of each order, we made visual estimates of prey consumption to the nearest 5%.

Temperatures were recorded hourly during sampling, using shielded thermisters placed near the suction trap at a height of 1 m. Temperatures were read to 0.1°C on a battery-powered telethermometer (Atkins Technical, Inc., Gainesville, Florida).

Bat activity was monitored by ultrasonic sensor (Techsonics, Inc., Taos, New Mexico) and visual observation. The sensor had a frequency range of 40 ± 5 kHz. Because of the small size of the winter population and the complication of simultaneous nuptial and foraging behavior, the trap did not clearly show the temporal pattern of feeding. Consequently activity was recorded at the north entrance of the roost. However, at the nursery site bat densities were high enough to permit measurement of foraging passes over the insect trap.

RESULTS—Dusk-to-dawn temperatures and nightly totals of bat passes and the abundance and diversity of insect samples are summarized in Fig. 1.

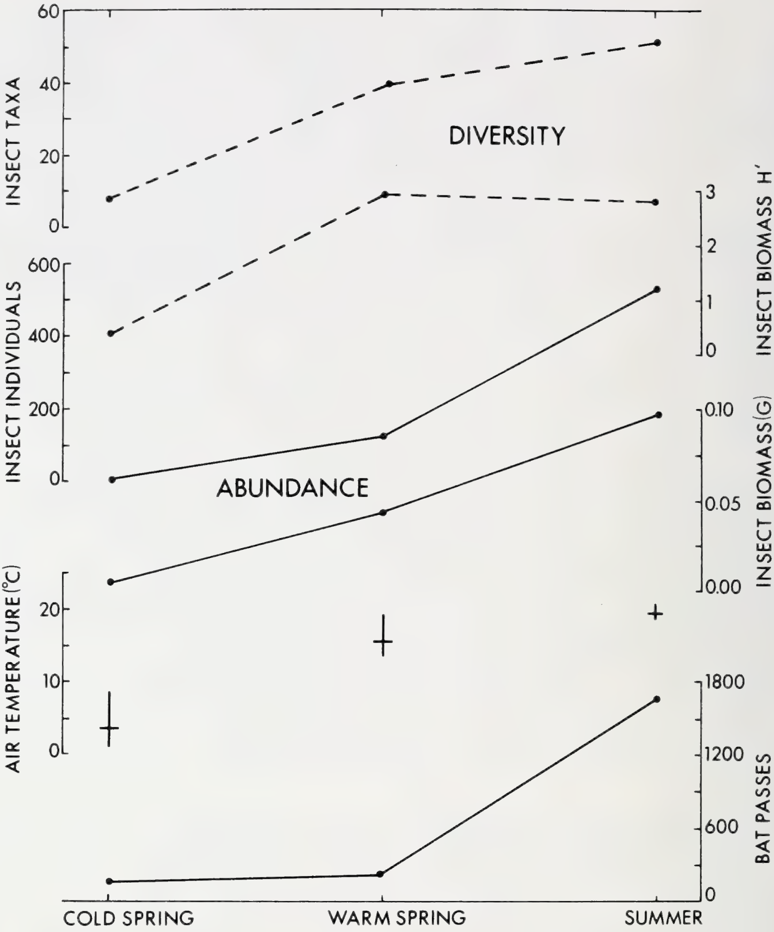

FIG. 1. Totals of *M. austroriparius* activity, insect abundance, and insect diversity, and mean and range of air temperature on 3 nights in northern Florida.

For all variables, the values were lowest on the cold spring night. Compared with the cold night, the insect sample on the warm spring night contained 10 times more individuals and biomass. Higher insect diversity on the warm night resulted from a 5-fold increase in the number of species and from greater equitability of the relative abundances of species. The insect sample on the early summer night further increased in abundance, with 4 times as many individuals and twice as much biomass as on the warm spring night, but the additional increase in diversity was modest.

All estimates of insect activity were weakly correlated with nightly mean temperature (Fig. 1; $r = 0.81$ for individuals, $r = 0.92$ for biomass, $r = 0.99$, $\underline{P} < 0.05$ for taxa, and $r = 0.96$ for biomass H′). With only 1 degree of freedom, most of the correlation coefficients were not statistically significant.

Composition of the volant insect communities (Fig. 2A) and the timing of insect flight activity (Fig. 2B) differed markedly among the 3 nights. On the cold spring night, Diptera was the only order of insects captured. Mosquitoes (Culicidae) and crane flies (Tipulidae) comprised 75% of the biomass sampled, and both were common in a peak of activity just after sunset. All but 4% of the night's insect biomass was taken in the first 4 hr after dark. On the warm spring night, 10 insect orders were captured, but Diptera, Coleoptera, and Lepidoptera (in rank order) accounted for most of the sample. Timing of insect activity was bimodal with 42% of the biomass captured in the first 1.5 hr and 30% in the last 3 hr. Flies were available almost all night, beetles occurred only in the first 1.5 hr after dark, and moths were active only in the first 4.5 hr. On the early summer night, 7 orders of insects were taken, and most were Lepidoptera, Diptera (mostly mosquitoes), and Coleoptera. The initial peak of activity was dominated by Diptera, which were caught in lesser numbers for most of the night. Coleoptera were captured only in the first 3 hr after dark. Noctuid and geometrid moths had distinctly bimodal activity, occurring in the first 1.5 hr and accounting for most of the activity during the morning hours. On all 3 nights, the largest insect biomass occurred soon after dark, one or more subsamples contained no insects, and no peak of insect activity occurred at dawn.

The total amount of bat activity during the 3 nights (Fig. 1) was strongly correlated with insect abundance ($r = 0.99$ for insect individuals, $r = 0.92$ for insect biomass) and more weakly related to insect diversity ($r = 0.74$ for insect taxa, $r = 0.46$ for biomass H'). The correlation of bat activity with the night's mean temperature was moderate ($r = 0.70$, not significant). During the cold spring night, feeding took place only in the first 3 hr after dark, coinciding with the only insect activity. However, bat flight continued through the cold night even though feeding did not occur and no food was available. Two foraging peaks occurred on the warm spring night, one at dusk when the insect community was diverse and one between 0100 and 0300 hr, when only Diptera were caught in the suction trap. Three activity peaks spanned the summer night—one at dusk, one from 2400 to 0300 hr, and one just before dawn; insect samples included only Lepidoptera and Diptera during the last 2 peaks.

On the cold night about half the bat passes occurred from 2300 to 0600 hr, when the air was very cold and no insects were available to eat. During this period, using ultrasonic sensors and light from a nearby streetlight, we observed numerous bats circling singly or in pairs about the roost entrance but heard few echolocation pulses. This behavior was reminiscent of nuptial "swarming" behavior that occurs in autumn at the entrances of caves in the cool temperate zones (Humphrey and Cope, 1976). On similarly cold nights in December and January, the bats had remained torpid inside the roost.

Food habits of the bats are in Table 1. The percent volume consumed may be compared with the insect biomass density that was available (Fig.

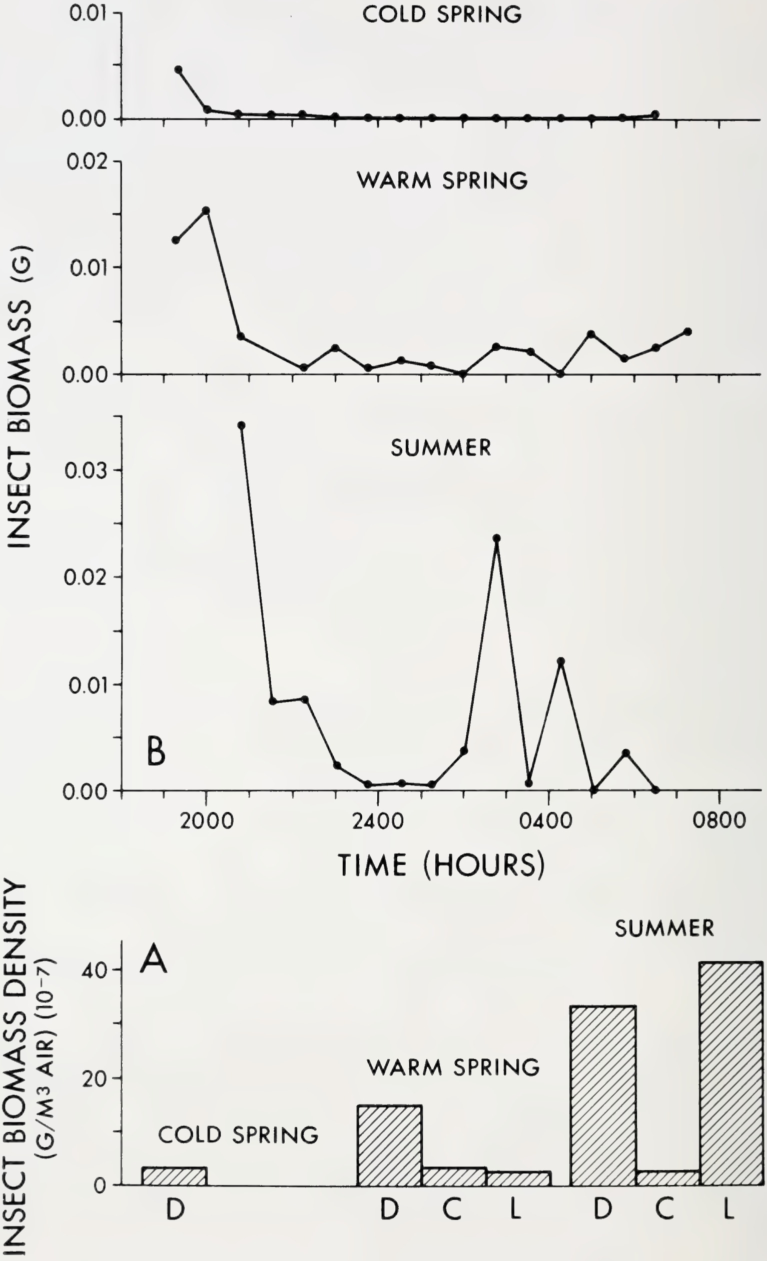

FIG. 2. (A) Relative density of the prominent orders of flying insects sampled by suction trap from dusk to dawn on 3 nights in northern Florida. Orders are Diptera (D), Coleoptera (C), and Lepidoptera (L). (B) Timing of total insect abundance in 45-min subsamples through the nocturnal activity of *M. austroriparius*.

TABLE 1. Food habits of *M. austroriparius* on 3 nights.

Night	Cold Spring	Warm Spring	Summer
Number of bat droppings	4	24	65
Prey selection (mean percent volume)			
Coleoptera	7.2	15.3	26.3
Lepidoptera	0	20.8	30.5
Diptera	92.8	63.9	43.1
Culicidae	10.0	46.2	27.6
Tipulidae	13.8	0	0
Moth scales per gram of feces (mean ± standard deviation)	0	181 ± 120	726 ± 132

2A). Only Diptera were sampled on the cold spring night, and they comprised most of the diet, along with a small amount of Coleoptera. Of the orders of insects available on other nights, the bats ate only Diptera, Lepidoptera, and Coleoptera, even though in other habitats this species is known to consume other orders (Ephemeroptera, Trichoptera; Zinn, 1977). Consumption of Coleoptera and Lepidoptera increased as the season progressed, while consumption of Diptera declined. However, these amounts in the diet differed significantly from the relative biomass of insects in the air (warm spring night, $G = 37.8$, $\underline{P} = < 0.005$; summer night, $G = 60.5$, $\underline{P} < 0.005$).

To evaluate desirability of potential prey encountered by foraging bats, preference values are in Table 2. On the cold spring night, the bats showed a weak preference for crane flies and mosquitoes among the Diptera; though a value cannnot be computed, presence of Coleoptera in the feces but not in the sample indicates a preference. A very strong preference for Coleoptera occurred on the warm spring and summer nights, along with moderate preferences for Lepidoptera and Culicidae; Tipulidae were available but not eaten. In view of the unchanging presence of beetles from warm spring to summer, and the expanding supply of moths and mosquitoes (Fig. 2A), this analysis shows a preference rank of Coleoptera, Lepidoptera, and Culicidae, with Tipulidae taken only when no more preferred food was available. Even stronger preferences for beetles and moths are indicated by their restricted periods of activity during the two warm nights. Continued consumption of the less preferred flies may have resulted from their activity at times when beetles and moths were unavailable.

In some insect orders, prey selection appeared to be related to prey size. Legs and antennae of Coleoptera in the feces were from beetles approximately 3-5 mm in body length. Beetles were smaller on the summer night (mean and range of weight 0.8 mg, 0.3-2.8 mg; length 3.6 mm, 3-5 mm; $n = 5$) than on the warm spring night, when the one trapped weighed 6 mg

TABLE 2. Preferences for prey individuals taken by *M. austroriparius* on 3 nights. Preference values are computed as relative frequency of the item in the diet/relative frequency of the item in trap samples (Reichman, 1975). Values greater than 1 indicate preference, and values less than 1 indicate avoidance.

Order or Family	Cold Spring Night	Warm Spring Night	Summer Night
Coleoptera	undefined	36.5	32.4
Lepidoptera	-	6.9	12.8
Diptera	1.0	1.0	0.5
Culicidae	1.5	8.6	4.1
Tipulidae	1.8	0.0	0.0

and was 8 mm long. Low selection of Lepidoptera on the summer night also may be related to prey size rather than taxonomic identity. Though moths were more abundant than on the warm spring night, they also were much larger (warm spring night, mean and range of weight 0.8 mg, 0.6-1.4 mg; length 4.3 mm, 3.5-7.0 mm, n = 6; summer night, weight 3.0 mg, 0.1-22.2 mg, length 6.1 mm, 3-28 mm, n = 16). On the cold spring night mosquitoes and crane flies were the largest active Diptera, as the rest were smaller chironomids and fungus gnats. Avoidance of crane flies on the warmer nights, on the other hand, was not related to size, for they were the same size as the much more abundant mosquitoes.

DISCUSSION—*M. austroriparius* has a distinctive life history pattern partly because the mild winter incompletely suppresses the availability of flying insects. Few or no insects fly on the very coldest winter nights (nights observed but not sampled), but only an average of 10 such nights occur yearly (U.S. Department of the Interior, 1970). On less severe cold nights a small food supply exists, limited in diversity and abundance. *M. austroriparius* on these occasions eats the foods that are available, has little choice in what it eats, but does exercise some selectivity toward the largest active flies—mosquitoes and crane flies. Many other kinds of adult insects occupy the local area but are inactive in cold weather, remaining hidden in refuges among vegetation and other substrates. These insects become active in warmer weather as the next continental front approaches, presenting the bats with a more abundant and diverse food supply. This intermittant food supply contrasts with the constant supply restricted to riparian habitat in tropical dry forest, where adult insects spend the stressful dry season in Costa Rica (Janzen, 1973).

On warmer nights from early spring to early summer, when a wide variety of prey are available, *M. austroriparius* is a generalist in selecting prey taxa, not specializing on a single order of prey as found for several bat species by Black (1974). However, *M. austroriparius* exercises considerable selectivity for 3 taxa—beetles, moths, and mosquitoes.

The seasonal pattern of foraging by *M. austroriparius* in the warm temperate zone contrasts strikingly with that of *Myotis lucifugus* in the cool temperate zone and with patterns of *Saccopteryx bilineata* in the tropical dry forest zone. Bradbury and Vehrencamp (1976) found complementary seasonal changes in insect abundance among nearby habitats in Costa Rica. *S. bilineata* moved among habitats seasonally in synchrony with changing food resources. Anthony and Kunz (1977) found that *M. lucifugus* in New Hampshire ate insect taxa nonselectively (above 3 mm in body length) during June and August, when insect availability was low and unpredictable, but that they were more selective in July when the preferred beetles and mayflies were abundant. Belwood and Fenton (1976) also found lactating female *M. lucifugus* to be selective feeders during July in southern Ontario. These 2 studies indicate that the optimal period for supporting *M. lucifugus* reproduction is only about 4-6 wk long. The optimal period of food availability for *M. austroriparius* is much longer, and the growing season from mating to recruitment of young is 4 months long. The longer growing season enables *M. austroriparius* to complete reproduction in spring and early summer without resorting to the 2-stage adaptation of bats of cool temperate zones, which have an autumn mating period, a pause during hibernation, and a spring-summer period for gestation and lactation. This comparison suggests that the autumn swarming period (see Humphrey and Cope, 1976) of cool temperate *Myotis* may serve to displace the costly mating behavior from spring to autumn because of the timing of suitable resources. Comparison of these tropical, warm temperate, and cool temperate studies indicates a gradient from year-round availability of food to a very short growing season. Florida's growing season is moderately truncated by a mild cold season and therefore is intermediate in length.

Seasonal differences in prey availability may influence colony size of *M. austroriparius* by limiting foraging density in winter and early spring, necessitating dispersal into numerous small colonies at that time. Formation of large nursery colonies is made possible by abundant insects in late spring and early summer. *M. austroriparius* conforms in the seasonal change of its colony sizes (large nursery colonies in summer, small colonies in the winter) to the pattern predicted by Dwyer (1971) for cave roosting bats in warm temperate zones. Our data indicate that the pattern involves prey availability as well as thermal properties of roosts.

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RANDOM DIGIT DIALING HOUSEHOLD SURVEY IN FLORIDA

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ABSTRACT: Two-stage cluster sample design was applied in the random digit dialing (RDD) household survey in Florida. The pilot survey in Sarasota County showed that this method reduced the proportion of unused numbers sharply; the chances of reaching eligible numbers were 31% in the primary sample and 44% in the cluster sample. The survey also showed that an evening interview had a better completion rate than did a daytime interview.

AS DEMAND GROWS for more information about households in the United States, more survey research of the population is being performed. At the same time, the cost of personal interview surveys continue to increase, forcing investigators to consider alternative methods of data collection in survey research. As a result, telephone surveys have gained much recent attention (Kahn and Groves, 1977; Glasses and Metzger, 1972). Some academic researchers, however, have been skeptical about the telephone survey due to the incomplete sample frame; not all households have telephones and not all telephones are listed in the telephone book.

In the last few years telephone surveys based on random digit dialing (RDD) (Cooper, 1964, Estlack, 1966; Glasser and Metzger, 1972; and Sudman 1973) have gained general acceptance among survey researchers. The RDD technique works to control sampling bias because all numbers, listed and unlisted, have an equal probability of being selected. The problem of the RDD sample is that the majority of the generalized random telephone numbers are nonworking household numbers.

To solve this problem, Waksberg (1978) introduced the 2-stage cluster RDD sample method. This method was compared by Grove (1978) with a design randomly generating 4 digit numbers within a working prefix number. He found that the cluster sample increased nearly threefold the proportion of working household numbers.

The question remains whether the exclusion of nontelephone households reduces the accuracy of a RDD survey. However, according to estimates by the U.S. Bureau of the Census, almost 93% of the households in the country had telephones by 1976. The study of Klecka and Tuchfarber (1978) concluded that RDD is at least as accurate as the personal interview survey.

Florida has experienced an explosive population growth in recent years. Since 1970 it has grown by 32%, a net addition of more than 2 million persons. The Bureau of Economic and Business Research (BEBR) in the University of Florida has provided the yearly estimates of Florida population by city and county. To aid these estimates and to engage more demographic and economic research, the BEBR has launched statewide household surveys which will provide more updated demographic information, average household size and seasonality composition of residents. I introduce the RDD sample technique to describe the general responses of a pilot study in Florida and discuss the feasibility of RDD technique.

2-Stage Cluster Sample—In the U.S., telephone numbers are constructed from 3 parts: 3-digit area code (AC), 3-digit prefix number (PF), and 4-digit random number (RN). Let the first 2 digits of RN be RN1 and the last 2 digits of RN be RN2, the 10-digit telephone number (TN) can be illustrated as follows:

(AC)	(PF)	(RN1) • (RN2)
3-digit	3-digit	4-digit Numbers
Area Code	Prefix Number	

For each AC-PF combination there are 100 possible combinations of RN1, and for each AC-PF-RN1 there are 100 possible numbers of RN2. In this 2-stage sample, cluster size K will be:

$$K = \frac{N}{M} \tag{1}$$

where N is a required sample size and M is the number of clusters in the primary sample. For total of P prefix number, the repetition r for each prefix number in the primary sample is:

$$r = \frac{M}{P}$$

$$\text{and } N = r \times P \times K \tag{2}$$

The Sampling Procedures: The telephone company usually assigns new telephone numbers in sequence. Therefore, locating at least one initial working residential number will increase the probability of reaching other residential numbers in the same cluster. The following 3 stages are involved in the 2-stage cluster sample for an assigned sample frame:

Step 1. Area Code (AC) and Prefix Number (PF): The area codes and prefix numbers are acquired from telephone company and the all combinations of AC-PF are listed.

Step 2. Primary Sample: A set of RN1 and RN2 is generated for a given AC-PF combination. This 10-digit number (AC-PF-RN1-RN2) is then dialed. If the response is residential, the number of AC-PF-RN1 will be retained and treated as a cluster of primary sample called a primary sample unit (PSU). This procedure of selecting PSU is repeated until a set of M clusters is located.

Step 3. Cluster Sample: Two digits random numbers of RN2 for a given cluster of AC-PF-RN1 in the primary sample are generated and dialed. If the response is residential, the number is treated as an element in the cluster. The procedure is repeated until the K elements are located. Thus, each number in ith cluster has equal probability, P_i, to be selected, i.e.,

$$P_i = \frac{R_i}{100} \tag{3}$$

where R_i is total residential numbers in ith cluster, i = 1, 2, . . . M.

Pilot Study—Sarasota County, Florida was chosen for the pilot study in the RDD household survey due to its fast growing and seasonality characteristics. Ninety-two percent of the households have telephones. The telephone area code of the county is 813. The list of 22 prefix numbers was provided by Florida Telephone Association.

A sample size N of 500 was chosen to reach a 95% confidence interval of a maximum of ± 5 percentage points for the responses to household size. In the primary sample, a set of twenty-five 4-digit random numbers, RN1 • RN2, was generated in each prefix number. Thus 550 random numbers were generated for those 22 prefix numbers. To reach the chosen number of cluster, M = 50, 300 numbers were dialed from those 550 pregenerated numbers.

The primary sample was performed during the day, 0900-1630, to differentiate the business numbers. The cluster sample was performed during the day and evening. The callback was done up to 4 times for the "no answer" or "busy signal" at different times on different days.

The status of sample numbers can be classified into 7 categories: no answer, busy signal, not in service, bad connection, refused, business and completed. The numbers of no answer, busy signal, not in service and business are farther classified as ineligible numbers; and completed, refused and bad connection numbers are classified as eligible numbers.

Result and Discussion—Five hundred seventeen interviews were completed in 3 wk after 1985 telephone calls were made. Some calls were made as many as 4 times. Among these 517 respondents, 53 were in the primary sample and 464 were in the cluster sample. In some clusters, interviewers were unable to locate predesigned 10 residential numbers, therefore, 3 additional clusters were located in the primary sample. The distribution of 7 response categories, as defined in the pilot study for the primary sample, the cluster sample and the overall sample are in Table 1.

The overall completion rate was 26%, refusal rate was 12%, and bad connection was 4%. The overall eligible number added up to 42%. For about every 2 telephone calls 1 number was eligible.

Improvement in the cluster sample over the primary sample is also shown in Table 1. The completion rate and eligible number rate were 28% and 44%, respectively, in the cluster sample, and 18% and 31%, respectively, in

TABLE 1. Sample distribution of telephone numbers in primary sample, cluster sample and overall sample.

		Primary Sample Number	%	Cluster Sample Number	%	Overall Number	%
Eligible	Completed	53	18	464	28	517	26
	Refused	27	9*	213	13*	240	12*
	Bad connection	12	4	57	3	69	4
	Subtotals	92	31	734	44	826	42
Ineligible	Business	19	6	92	5	111	6
	Not in service	144	48	264	15	408	20
	No answer	39	13	300	18	339	17
	Busy signal	6	2	295	18	301	15
	Subtotals	208	69	951	56	1159	58
	Totals	300	100	1685	100	1985	100

This refusal rate is proportion to total number dialed; it is different from the refusal rate among respondents.

TABLE 2. Percentage distribution of the daytime interview and the evening interview.

		Daytime Interview	Evening Interview
Eligible	Completed	20	23
	Refused	10*	13*
	Bad connection	8	4
	Subtotals	38	40
Ineligible	Business	5	2
	Not in service	11	8
	No answer	26	23
	Busy signal	20	27
	Subtotals	62	60
	Totals	100	100

the primary sample. Not-in-service numbers (48%) and the ineligible numbers (69%) were also decreased significantly in the cluster sample to 15% and 56%, respectively. The numbers of bad connection, business, and no answer were approximately equal in both samples. The only category that did not show the sign of improvement was the busy signal. The busy numbers increased to 18% in cluster sample from 2% in the primary sample.

The refusal rate among respondents was computed as the proportion of the refused numbers to the total response numbers. The overall refusal rate was 32%. This 68% response rate was about national averages of nonfederal telephone survey (NRC, 1979).

The cluster sample was conducted during the day and the evening. The results of both interviews are in Table 2. The completion rate (23%) was higher in the evening interview (EI) than the 20% in the daytime interview (DI). The percentages of bad connection, business, no answer and not-in-service numbers were decreased in the EI. The busy signal, however, was increased from 20-27% during the evening. The refusal rate for all respondents (34%) was slightly higher in the EI than in the DI (32%).

About 60% of the total number of telephone calls were either no answer, busy signal or not-in-service. How to decrease these ineligible calls in the future RDD survey needs to be studied.

According to the telephone company, nonworking telephone numbers are supposed to be recorded in recording machines which will inform the caller that the number is not-in-service. However, some numbers are not recorded, and even if they were recorded, when the machine is busy they will respond with a busy signal or no answer when people dialed. This means that survey callers may keep trying to reach a "busy" or "no answer" number which in fact is not-in-service. This delay is a major handicap in completing the survey.

Even though an average interview took only 5 min, to obtain these 517 completed interviews the interviewers took a total of 200 hr. In other words, an interviewer finished only 2.6 interviews in 1 hr. The rest of the time was spent to record the results of each telephone call and dialing the numbers. A good recordkeeping system was established in this survey. The records provided the final disposition of each number attempted as shown in Tables 1 and 2. It also provides information and guidance for a future RDD survey.

Summary and Conclusions—Waksberg's 2-stage cluster random digit dialing sample technique was adopted to study the household survey in Sarasota County, Florida. The 53 numbers of cluster were chosen in primary sample, and 10 samples were selected in each cluster sample. A total of 517 households participated in the survey after 1985 telephone numbers were dialed. Thus, the completion rate was 26%. In general, this 2-stage RDD technique was quite applicable in the pilot study in Sarasota County.

The refusal rate for all the responded households was about 32% which was close to the national average of nonfederal telephone surveys. The business numbers in both samples were only 5% which was lower than the expected percentage. Not-in-service numbers varied from 48-15%, and the busy signal varied from 2-18% from the primary sample to cluster sample. The completion rate varied from 18-28%, and the eligible number rate varied from 31-44% from the primary sample to the cluster sample. This implies that the 2-stage cluster sample has shown significant improvement over simple random sample because the primary sample is a design randomly generated 4 digit numbers within a working prefix number.

Decreasing the 60% ineligible telephone numbers has become our major concern in future surveys. The cooperation of the telephone company to provide more information of working bank of numbers within the prefix will certainly reduce the problem of dialing ineligible numbers and will increase the efficiency of our survey program.

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A COMPARATIVE STUDY OF *DIPLECTRUM FORMOSUM* AND *D. BIVITTATUM* (PISCES: SERRANIDAE)

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Abstract: *Specimens of the simultaneously hermaphroditic fish species* Diplectrum formosum, *the sandperch, and* D. bivittatum, *the dwarf sandperch, were collected near the Dry Tortugas, Florida, by means of shrimp trawl during December 1976. Stomach contents of 326* D. formosum *(100 empty) and 325* D. bivittatum *(131 empty) revealed little or no differences in their food habits relative to number and volume of food items, size of food items or the contribution, in grams, each food item makes to each fish. Both species primarily consumed amphipods, shrimp, crabs, fish, and polychaetes. Temporally, both species fed at the same 2 diurnal periods. Species were collected sympatrically but there were areas where each species dominates in relative abundance.*

Few recent published studies exist on various aspects of the life histories of simultaneously hermaphroditic sea basses (Bortone 1971, 1977a; Hastings 1973; Hastings and Bortone in press). To fully evaluate the life history strategies of fishes having this reproductive mode it is important to examine the competitive interaction of closely related species. As information becomes available it will be possible to assess evolutionary and ecological hypotheses pertinent to hermaphroditic life history strategies. Additionally, hermaphroditic sea basses are often common to reef or near-reef biotopes and comparative life history data will add to our understanding of these communities. To this end, aspects of the feeding habits and relative abundances of *Diplectrum formosum* and *D. bivittatum* are presented herein.

Materials and Methods—Specimens were collected day and night from 11-13 December 1976 by shrimp trawl from the FRS/V OREGON II, Cruise no. 72 conducted in the vicinity of 24° 44-52′N and 82° 22-39′W, an area 32-67 km ENE of the Dry Tortugas, Florida, at a depth of 29-33 m. Specimens were sorted and frozen within 20 min after landing. In the laboratory the specimens were weighed to the nearest 0.1 g and measured for standard length (SL) to the nearest millimeter. Stomachs (including the esophagus but excluding the intestine) were removed and preserved in 10% Formalin. Later the contents were removed, sorted to the lowest possible taxonomic level and counted. Also, displacement volume of each food item category was determined to the nearest 0.1 ml.

Spearman rank correlation coefficients were used to statistically compare food items between species as suggested by Fritz (1974). Food item diversity (H′) was calculated according to Poole (1974).

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Results—The length-frequency histogram for the 2 species, *D. formosum* and *D. bivittatum*, collected in the study area is in Fig. 1. The parameters of the length-frequency distribution were: mean = 110.41 mm SL, standard deviation = 33.82, minimum-maximum SL = 50-170 mm for *D. formosum;* and 97.00 mm SL, 19.47, 65-120 mm for *D. bivittatum*. Hartley's F-max test performed on length distribution variances indicated that variances of the population length for each species were significantly different ($P < 0.05$, $F = 3.02$, df = 1). The 2 species, therefore did not share the same population structure with regard to size. There was, however, a total overlap in the size of *D. bivittatum* by *D. formosum* and because the jaw structures are similar (Bortone 1977b) there is a potential for competition for food resources.

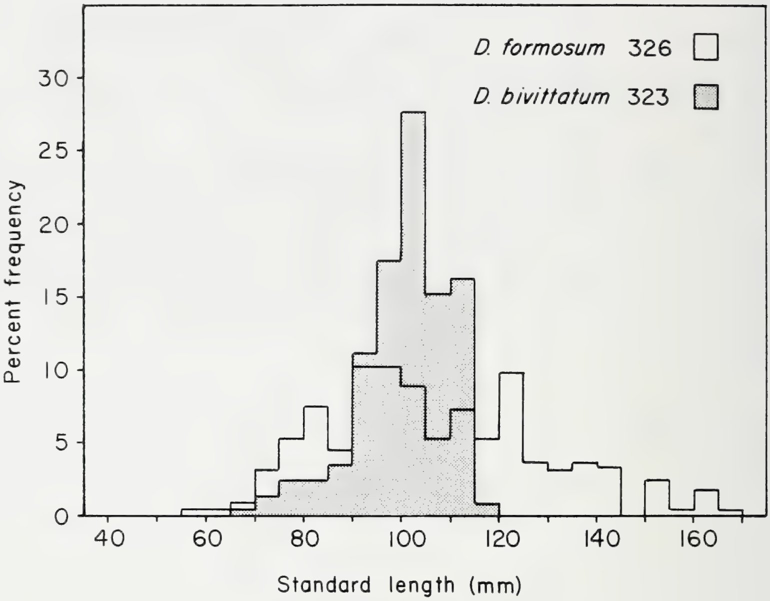

Fig. 1. Length-frequency histogram of *Diplectrum formosum* and *D. bivittatum* collected in the study area.

Stomach contents examination indicates that feeding habits of *D. formosum* and *D. bivittatum* in this study were similar (Table 1). Both species fed primarily on amphipods, natantian shrimp, and brachyuran crabs with regard to number of items. They also consumed fish and polychaetes to a lesser extent. By volume fish, shrimp and crabs were the most important items eaten. The crustaceans consumed were identified as: shrimp-*Alpheus floridanus*, *Thor* sp., *Sicyonia brevirostris*, *Periclimenes* sp., *Solenocera* sp.; amphipods-*Caprella* sp.; crabs-*Portunus* sp., *Speocarcinus lobatus;* stomatopods-*Eurysquilla plumata*, *Squilla chydaea*, *Squilla heptacantha*.

TABLE 1. Stomach content analyses of 326 *Diplectrum formosum* (f, 100 empty) and 325 *D. bivittatum* (b, 131 empty). The symbol (-) indicates that the measured volume displaced less than 0.1 ml. The symbol (*) indicates there is an association between f and b at the 0.1 level of significance using the Spearman rank correlation coefficient.

	% No.		No./fish		% Vol.		Vol./fish (µl)		Vol./item (µl)		Vol. (µl)/item/ gram of fish	
Food Item	f	b	f	b	f	b	f	b	f	b	f	b
Nematoda	1.3	0.9	0.05	0.05	-	-	-	-	-	-	-	-
Polychaeta	2.2	1.3	0.08	0.05	4.8	5.5	20	16	232	214	5.80	9.70
Unidentified worms	0.7	0.5	0.03	0.03	-	-	-	-	-	-	-	-
Natantia	21.5	48.7	0.83	2.63	20.7	37.7	84	106	102	40	2.54	1.83
Brachyura	8.5	3.5	0.33	0.19	13.0	4.2	53	12	161	62	4.03	2.81
Stomatopoda	0.9	0.4	0.04	0.02	4.9	1.1	20	3	563	150	14.09	6.70
Mysidacea	0.7	0.4	0.03	0.02	0.1	-	1	-	17	-	.42	-
Cumacea	0.3	0.4	0.01	0.02	-	-	-	-	-	-	-	-
Ostracoda	0	0.3	0	0.02	0	-	0	-	0	-	0	-
Amphipoda	29.5	25.7	1.14	1.39	0.3	0.4	1	1	1	1	.03	.03
Unidentified Crust.	16.1	13.0	0.62	0.70	12.5	10.8	51	30	82	43	2.06	1.96
Diptera	0	0.1	0	0.01	0	-	0	-	0	-	0	0
Mollusca	3.5	0.5	0.13	0.03	1.2	0.4	5	1	37	40	.92	1.81
Ophiuroidea	6.4	0.2	0.23	0.01	5.8	0.6	24	2	95	150	2.37	6.79
Pisces	6.1	3.5	0.23	0.19	31.2	35.7	127	101	542	527	13.56	23.85
Unidentifiable	2.3	0.7	0.09	0.04	5.6	3.7	23	10	255	250	6.39	11.31
Significance	*		*		*		*		*		*	

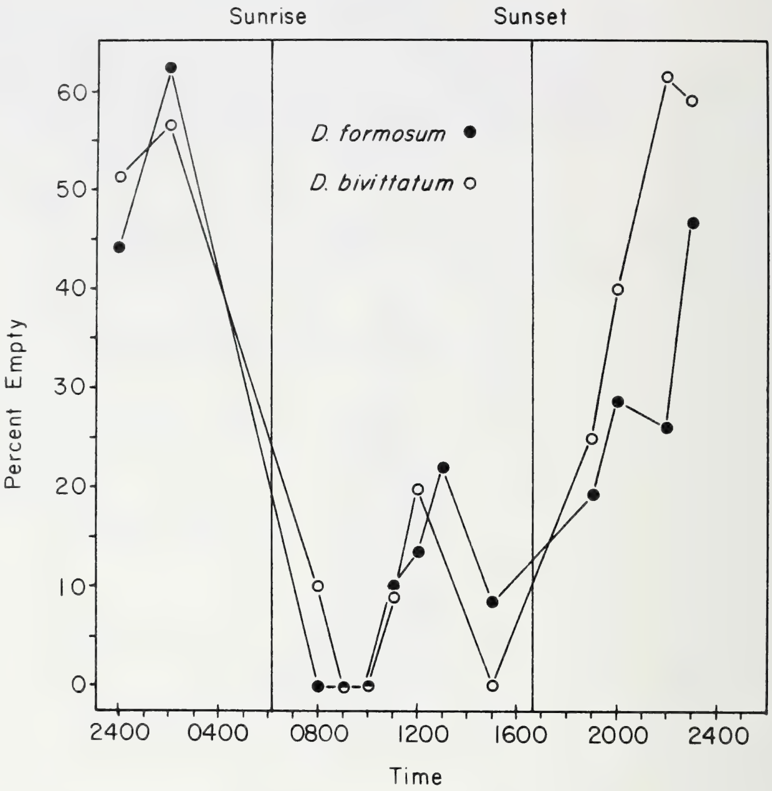

FIG. 2. Feeding activity of *Diplectrum formosum* and *D. bivittatum* (ordinate is percentage of fish having empty stomachs, abscissa is the time of day).

Diplectrum formosum consumed more fish and brittle stars (Ophiuroidea) than did *D. bivittatum.* Additionally, shrimp proportionately comprised a greater part of the diet by number for *D. bivittatum.* In general, *D. formosum* consumes nearly the same food items by frequency as *D. bivittatum,* but *D. formosum* consumes these items more evenly (H′ = 2.01 and 1.49 for *D. formosum* and *D. bivittatum,* respectively). Species also consume similar food items with regard to volume, as noted by volume per individual fish and volume per item per gram of fish (Table 1). There was a tendency (but statistically nonsignificant using a Spearman rank correlation coefficient) for *D. formosum* to consume larger food items than *D. bivittatum.* This is expected considering the larger average size of *D. formosum.* We conclude that the population of *D. formosum* consumes similar food items in the same proportion by number and volume as does *D. bivittatum.*

Next we examined the aspect of temporal segregation with regard to feeding. Figure 2 and Table 2 show a comparison of the 2 species with regard to the percentage of fish having empty stomachs versus time of collection. Inspection of Fig. 2 indicates a similar sequence of feeding activity for both

TABLE 2. Feeding activity data for *Diplectrum formosum* and *Diplectrum bivittatum*. The number of fish examined is the denominator, number of fish with empty stomachs is the numerator and percent empty is in parentheses.

Time of Day	*D. formosum*	*D. bivittatum*
0000	16/36 (56)	12/23 (52)
0200	13/21 (62)	17/30 (57)
0800	0/2 (0)	1/10 (10)
0900	0/8 (0)	0/6 (0)
1000	0/1 (0)	0/9 (0)
1100	1/10 (10)	1/11 (9)
1200	1/8 (13)	1/5 (20)
1300	2/9 (22)	
1500	1/12 (0)	0/6 (0)
1900	4/21 (19)	18/71 (25)
2000	26/89 (29)	24/60 (40)
2200	18/69 (26)	28/45 (62)
2300	18/38 (47)	29/49 (59)

species. Fewer empty stomachs were found in both species collected at mid-morning and mid-afternoon than any other time of day. These fishes generally reduced their feeding activity at about 1200. An analysis of variance test indicated that there was no statistical difference ($P<0.05$, $F=0.50$, df = 1, 23) between the feeding activity of the 2 sea basses.

Our field data indicated that these 2 species were not equally distributed with regard to abundance (Table 3). A Spearman rank correlation coefficient between abundance of each species by station indicates no interspecific association of abundance ($P > 0.10$, df = 21). Collection stations, however, can be assigned to 2 geographic zones (north and south of 24° 49′). Assuming trawl sample abundance is proportional to population abundance, students' t-test shows significant differences in abundance between the species. North of 24° 49′ *D. formosum* is more commonly captured than *D. bivittatum* ($P < 0.01$, $t = 3.28$, df = 8) and south of 24° 49′ *D. bivittatum* is captured more commonly than *D. formosum* ($P < 0.01$, $t = -4.27$, df = 11).

DISCUSSION—Our examination of some of the biological parameters of sympatric populations of *D. formosum* and *D. bivittatum* indicates a high potential for food resource competition. The size distribution of the 2 species overlap and both are commonly collected simultaneously. Comparative analysis of the stomach contents reveals there are few or no differences between the 2 species in their feeding habits. Similarly, there are no apparent differences in time of feeding. The 2 species can apparently coexist while consuming the similar food items at the same time by adapting a feeding behavior or a mechanism of feeding which may help avoid competition, or, there may be temporal segregation on a fine level that our analyses did not detect. The former is unlikely given that their jaws, dentition, and gill rakers

TABLE 3. Number of individuals of *Diplectrum formosum* and *D. bivittatum* collected at each 15 min sampling station. Mean ($\bar{x}$) and standard deviation (sd) are presented for collections North and South of 24° 49′N.

	FRS/V OREGON II	No. Individuals	
	Station No.	*D. formosum*	*D. bivittatum*
	21278	69	13
	21280	48	6
	21282	24	4
	21284	18	1
	21286	14	0
	21288	8	6
	21289	6	1
	21290	7	0
	21291	9	0
	21292	12	3
N			
24°49′		$\bar{x}$ = 21.50 sd = 19.78	$\bar{x}$ = 3.40 sd = 3.90
S	21258	19	53
	21259	20	47
	21262	21	39
	21264	4	45
	21266	18	22
	21268	7	30
	21270	2	10
	21271	1	9
	21272	4	10
	21273	1	5
	21275	0	3
	21276	4	18
		$\bar{x}$ = 8.42 sd = 8.41	$\bar{x}$ = 24.25 sd = 17.91

are proportionately similar (Bortone, 1977b). At present we cannot reject the latter hypothesis but an activity study by Bortone (1971) on *D. formosum* from the northern Gulf of Mexico substantiates the active-inactive pattern revealed in the present study. Local differences in population abundance may also help species avoid competition. For example, abrupt changes in substrate type and local preference by each species may account for their partial disassociations in the Tortugas area. Alternatively, these species may not have been limited by food in the study area during the time of our study. Zaret and Rand (1971) have demonstrated that shifts from nonoverlap to overlap in food resources may be due to temporal changes in abundance of food items.

Bortone (1971) indicated that the food of *D. formosum* from the northern Gulf of Mexico (an area in which *D. bivittatum* is rare or absent, Bortone 1977b) consisted mainly of shrimp, crabs, amphipods and fish. Similarly, *Diplectrum macropoma* and *D. pacificum* collected from the Bay of

Panama consumed primarily shrimp, stomatopods and fish (Bortone, 1977a). In that study there was statistical evidence that the larger species, *D. pacificum*, consumed larger items and ate more fish than *D. macropoma*. This same tendency may occur among *Diplectrum* individuals within a species, but this has not been verified.

In examining data from our study and from previously published studies on *Diplectrum* we conclude there are few differences in food items of *Diplectrum* spp. which occur sympatrically. Their food habits probably reflect local availability and abundance of prey items. There may, however, be some competitive exclusion due to competition which results in segregation based on substrate preference (microhabitat).

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LARGE VERTICAL SALINITY GRADIENTS IN THE FT. PIERCE INLET ASSOCIATED WITH HURRICANE DAVID

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Abstract: *The passage of Hurricane David had dramatic effects on the surface to bottom salinity gradient recorded in the Ft. Pierce Inlet. The Inlet is located in the Indian River on Florida's Atlantic coast. Salinities measured at meter intervals from surface to bottom, 12 da before the passage of the Hurricane, showed the water column to be vertically homogeneous. Eight da after the Hurricane, the water column was highly stratified during the ebb tide with a maximum surface to bottom salinity difference of 11.9 ppt. The flood tide was homogeneous after about 2 hr. Thus, the extensive rainfall during Hurricane David changed what was a well-mixed inlet into a highly stratified one during the ebb tide.*

I report the effects of Hurricane David on the vertical salinity gradient in an ordinarily well-mixed inlet. I did this by measuring salinity at different depths in the inlet approximately 1 wk before and after the passage of the Hurricane.

Similar studies have shown that other Florida Atlantic estuaries are also typically homogeneous or show little difference in salinity with depth. Van de Kreeke (1978) has shown that the Marco River in Florida has a surface to bottom salinity difference of only 2 ppt during the rainy season (June-September), and is vertically homogeneous during the dry season (October-April). Lee and Rooth (1976), working with salinities in Biscayne Bay, have shown this area to be vertically homogeneous with respect to salinity during most of the year. They do find some stratification along the western boundary during times of heavy runoff.

Von Zweck and Richardson (1980) have shown that the Ft. Pierce Inlet is also nearly vertically homogeneous. They did find what was termed a salt wedge, but the surface to bottom salinity gradient did not appear to be greater than 2 ppt. Youngbluth (pers. comm.) also measured salinities in the inlet, and found the vertical salinity gradient rarely exceeded 1.5 ppt, even during the rainy season.

Hurricane David passed through the Ft. Pierce area on 3 September 1979. The Ft. Pierce Coast Guard Station (0.5 km from the study site) recorded 22.7 cm of rain associated with the Hurricane and maximum winds of 153 km/hr. The water level in the Ft. Pierce Inlet was increased by approximately 95 cm above the mean water level recorded before the Hurricane's passage.

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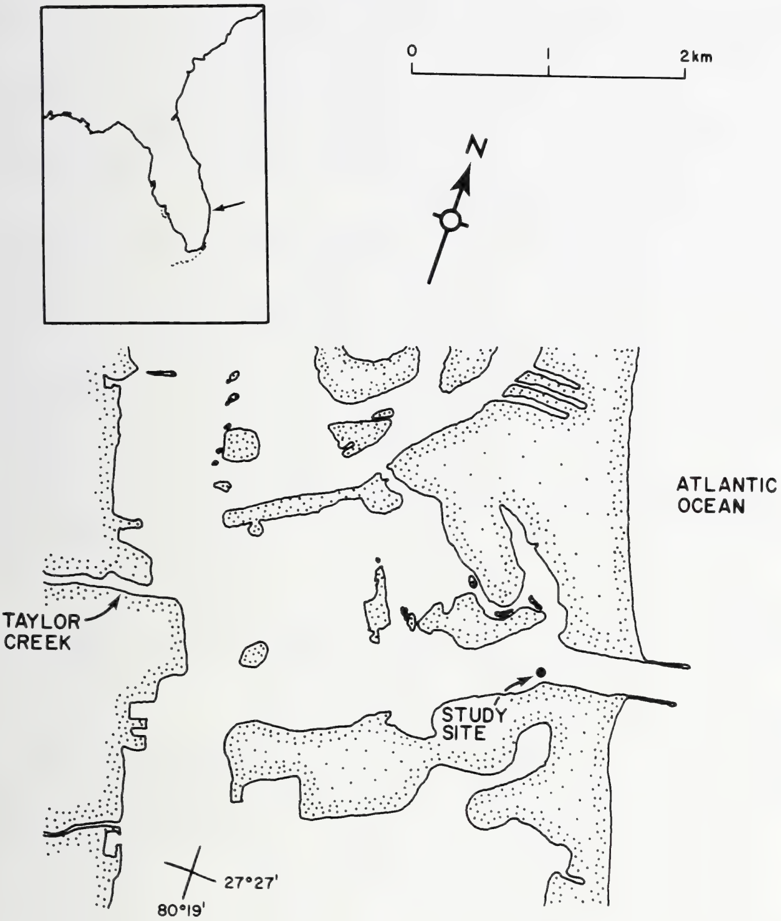

FIG. 1. The Ft. Pierce Inlet connecting the Indian River with the Atlantic Ocean.

The major freshwater influence on the Inlet is from Taylor Creek (Fig. 1), a drainage canal regulated by a series of locks. Vertical mixing is evidenced in the Inlet by large eddies and upwelling areas caused by bottom irregularities.

The principle result of this study is there was a large surface-to-bottom salinity gradient during the ebb tide in the Ft. Pierce Inlet. This gradient was much larger than what had been previously observed in an estuary of this type, with the Inlet exhibiting almost fjord-like characteristics. It seems then, that Hurricane David produced enough rainfall to cause stratification in an area where it was not previously reported.

STUDY AREA—The study area was located in the Ft. Pierce Inlet (27°28′N, 80°18′W) which connects the Indian river to Florida's Atlantic coast (Fig. 1). The boat used for sampling was anchored fore and aft to maintain station during tidal shifts. The water depth at the site averaged 7 m. A temperature-conductivity profile was taken at meter intervals from the surface to the bottom using a Beckman field salinometer with an accuracy of ±0.5 mmhos/cm and ±0.5°C according to factory specifications. Water samples were taken from the surface and bottom to calibrate the salinometer. Conductivity and temperature were converted to salinity using the method defined by Bennett (1976).

The tide moves into the inlet as a progressive wave, and has a mean range of 1 m (Smith, 1980). The ratio of the diurnal to the semi-diurnal tidal constituents (the form number) was 0.33, classifying the tide at the Inlet as mixed, but predominantly semi-diurnal. The Inlet is dredged to a nominal depth of 12 m, and is stabilized on both sides of the mouth by rock jetties.

The prehurricane sampling extended from 1545 to 2400 EST on 11 August 1979, and spanned the second half of one ebb tide and a complete flood. The posthurricane sampling began at 0700 EST on 10 September 1979, and continued until 0300 EST on the 11th. This period included 2 complete flood currents and 1 complete ebb. The sampling interval varied from 15 to 30 min, depending on the tidal stage and the stratification of the water column.

Results—The prehurricane sampling showed the water column to be well mixed. At the end of the ebb, the surface salinity was 34.5 ppt and the bottom was 35.2 ppt, a difference of only 0.7 ppt.

After the Hurricane, the surface-to-bottom salinity gradient was large during all of the ebb, and the first part of the flood (Fig. 2). At slack water after the flood, the water column was homogeneous with a salinity of 34.6 ppt. During the ebb which began at 1500 EST, the bottom salinity dropped to 31.0 ppt and the surface salinity reached a minimum of 19.1 ppt, a difference of 11.0 ppt. Similar stratification was observed at the end of the previous ebb.

After the flood tide began, the surface and bottom salinities climbed rapidly to the 34.6 ppt value. The water column was again homogeneous approximately 2 hr into the flood tide.

A more detailed examination of the salinity gradient during the ebb tide showed there did not appear to be a sharp halocline between the low salinity surface water and the higher salinity bottom water (Figs. 3 and 4). Instead, there was a gradual reduction in salinity from the surface to the bottom. The possible exception to this occurred near the 32 ppt isopleth at 1530 EST (Fig. 4). The general trend was for the surface salinities to decrease faster than the bottom salinities during ebb, with maximum stratification occurring at the end of the ebb tide.

Discussion—As the tide begins to ebb, there is an immediate difference between the surface and bottom salinities. This is caused by the drainage from Taylor Creek moving through the Inlet over the higher salinity estuarine water. During nonhurricane time periods, the output from Taylor

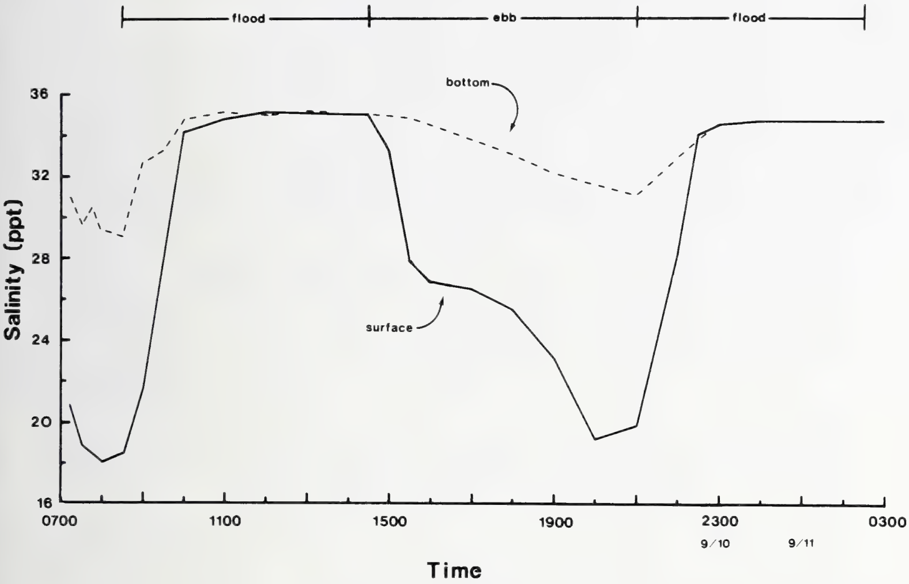

FIG. 2. Time variation in surface and bottom salinities at the Ft. Pierce Inlet. 0700 EST, 10 September through 0300 EST, 11 September 1979. See Fig. 1 for station location.

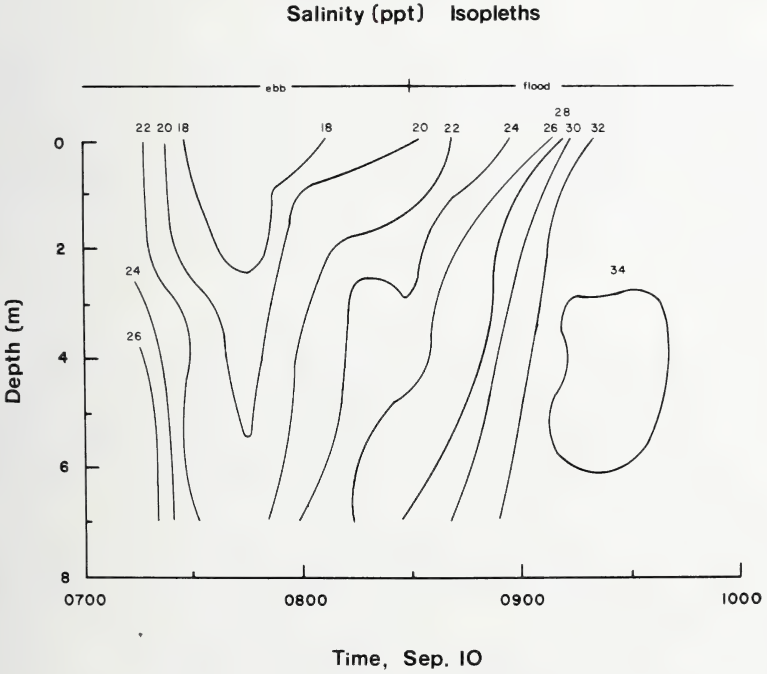

FIG. 3. Time-depth variations in salinity at the Ft. Pierce Inlet. 0700 EST to 1000 EST, 10 September.

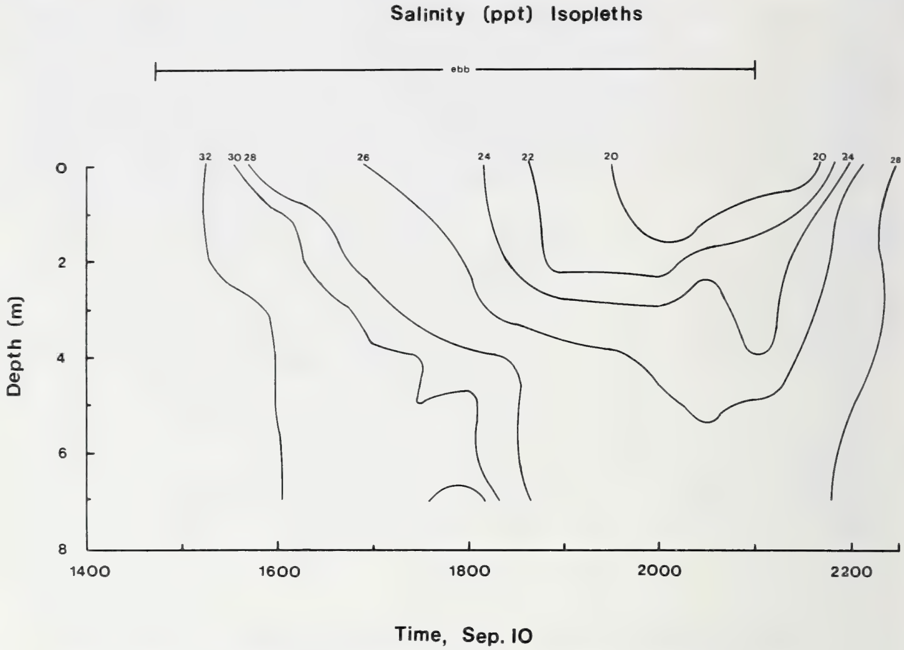

FIG. 4. Isohalines in the Ft. Pierce Inlet from 1400 EST to 2230 EST, 10 September.

Creek is small enough so that the mixing processes in the estuary create a homogeneous or only slightly stratified water column. However, because of the extensive rainfall during the Hurricane, the additional output from Taylor Creek could not completely mix with the estuarine water mass. The lack of distinct halocline indicates that some mixing was occurring between Taylor Creek and estuarine waters. If there were no mixing, there would have been a much sharper division between the surface and bottom salinities.

The significance of this work is most important when considering the relatively small amount of posthurricane data available for an estuarine location, particularly along Florida's Atlantic coast. The vertical salinity gradient observed in the Ft. Pierce Inlet after the passage of Hurricane David was 6 times greater than the maximum 2 ppt gradient which occurs in other estuaries along the Florida coast, and 17 times greater than the surface to bottom salinity difference observed before the Hurricane.

ACKNOWLEDGMENTS—Lew Gilliland devoted much time and effort to the sampling program. Ned P. Smith made valuable suggestions on the manuscript and helped with the field work. Nancy Hasty also helped with the field work. This work represents Harbor Branch Contribution #189.

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Agricultural Sciences

EVAPOTRANSPIRATION AS RELATED TO CLIMATIC FACTORS IN SOUTH FLORIDA

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ABSTRACT: *Evapotranspiration (ET) is an important process of the hydrological cycle, but it is difficult to be accurately estimated. When adequate records of ET for a crop are not available, 2 empirical formulae are commonly used to estimate ET: pan evaporation method and Blaney-Criddle method. According to the results made from both correlation and multiple regression analyses between pan evaporation and climatic factors, it was found that solor radiation was the most important factor affecting ET; temperature was the next important factor. Based on that, the Blaney-Criddle method was modified by using the solar radiation. The result showed that the modified Blaney-Criddle method was more applicable than the other 2 methods. The actual record data of ET for sugarcane, sawgrass, alfalfa, bahiagrass, bare soil, and cane trash were used to establish the evapotranspiration coefficients, which varried with vegetation types and time.*

EVAPOTRANSPIRATION (ET) is an important process of the hydrologic cycle. Approximately 75% of the total rainfall on the continental basis is returned to the atmosphere by evaporation and transpiration (Gray, 1970). The ET represents the quantity of water which must be supplied at all times to maintain a soil water balance. A knowledge of ET is necessary in planning and implementing soil water management systems. The following methods are frequently used to estimate ET: mass transfer, energy budget, water budget, moisture budget, and groundwater fluctuations. Each method has its own advantage and disadvantage for use in practical application. None of these methods are applicable under all conditions. The type of data required depends on the intended use (Linsley et al, 1958). However, no matter what method is used, all are either directly or indirectly correlated to the climatic conditions.

When adequate records of ET for a crop are not available, empirical formulae are used to estimate ET. One of the empirical formulae is the pan evaporation method which is widely used to estimate the amounts of evaporation from lake and reservoirs. The pan evaporation method is inexpensive and easy to operate. Generally, the United States Weather Bureau Class A Pan is installed in most weather stations in conjunction with other instruments for measuring the climatic factors. Thus, pan evaporation is an important index for quantifying water on the earth returning to the air as correlated to the climatic factors. In this study I: (1) investigate the relationship between pan evaporation and climatic factors by using both correlation and multiple regression analyses; (2) estimate ET from pan evaporation and Blaney-Criddle methods; (3) modify the Blaney-Criddle method by using a most important climatic factor influencing the evaporation; and (4) evaluate the evapotranspiration coefficients based on the methods of pan evaporation, Blaney-Criddle, and modified Blaney-Criddle.

MATERIAL AND METHODS—Climatological data were obtained from the weather station located at the University of Florida's Agricultural Research and Education Center (AREC) at Belle Glade. The data include minimum, maximum and mean air temperatures, solar radiation, rainfall, pan evaporation, wind motion at 60 and 600 cm above the ground, minimum and maximum soil temperatures (10 cm below the bare soil surface), the time (hours) for relative humidity over 90% (the ratio of the actual vapor pressure to saturated water vapor pressure at the same temperature), the minimum percentage of relative humidity, and continuous period (hours) of wetness (that moisture from either rain or dew stays on foliage). The daily data of 1978 and 1979 were summarized by Allen (1979, 1980). These 2 yr of daily data were resummarized on weekly and monthly basis. These daily, weekly and monthly data were used to correlate pan evaporation with the other climatic factors.

To observe the longer period of climatic factors related to pan evaporation, 52 yr (1924-75) of data of pan evaporation, mean air temperature, and rainfall and 5 yr (1971-75) of solar radiation data are in Table 1. The possible sunshine hours which were obtained from Tampa International Airport Weather Station are also in Table 1.

The water requirements of crops at Florida Everglades were studied by Clayton (1949) and Shih and Gascho (1980). The study included 3 yr for sugarcane, 7 yr for sawgrass, 4 yr for bare soil, 6 yr for cane trash, 2 yr for alfalfa, and 1 yr for bahiagrass. These data are in Table 2.

Evapotranspiration Calculation: As mentioned in the introduction, when adequate records of ET for crop are not available, 3 common empirical formulae are used to estimate ET: pan evaporation method, Thornthwaite (1948) method and Blaney-Criddle (1950) method. However, Tanner (1967) indicated that the temperature lagging radiation will affect the accuracy of estimation. As Table 1 shows, the maximum solar radiation occurred on April, but the maximum temperature lagged by about 4 mo. In

Table 1. Average rainfall, temperature, pan evaporation, solar radiation, and possible sunshine data.

Month	Rainfall	Mean Temperature	Pan Evaporation	Solar Radiation	Possible Sunshine		
					Measured	Base* Ration	% of Annual
	cm	°C	cm	Ly/day	hrs.		
Jan	4.52	17.22	8.43	282	10.60	0.91	7.27
Feb	4.65	17.78	9.93	340	11.21	0.87	7.69
Mar	7.64	19.44	14.81	436	12.00	1.03	8.23
Apr	7.59	21.67	16.61	510	12.83	1.07	8.80
May	12.09	23.89	18.03	507	13.53	1.17	9.28
Jun	23.77	25.56	15.82	472	13.89	1.16	9.53
Jul	21.06	26.67	15.87	452	13.72	1.18	9.41
Aug	20.42	27.22	15.60	447	13.06	1.12	8.96
Sep	21.92	26.67	13.03	405	12.31	1.03	8.44
Oct	12.55	23.99	11.81	370	11.49	0.99	7.88
Nov	5.13	20.56	9.30	302	10.77	0.90	7.39
Dec	3.96	17.78	7.82	281	10.41	0.90	7.14
Total	146.0		157.06	4804	145.81	12.33	100.00

* (measured hours/12 hr) × (actual days of month/30 da).

TABLE 2. Average evapotranspiration (ET) from lysimeters of soil and vegetation. The monthly ET factor estimated by the methods of Blaney-Criddle (B) Modified Blaney-Criddle (C).

Month	Sugarcane[1] (3 years)	Sawgrass[2] (7 years)	Bare Soil[2] (4 years)	Cane Trash[2] (6 years)	Alfalfa[2] (2 years)	Bahiagrass[2] (1 year)	B	C
				cm				
Jan	4.53	9.34	4.72	1.17	5.61	6.60	11.63	9.39
Feb	3.51	8.63	5.79	1.45	6.78	7.29	12.29	11.51
Mar	8.01	11.91	7.72	1.75	8.35	12.52	14.00	15.43
Apr	10.81	15.72	10.31	1.70	12.52	13.39	15.87	19.15
May	15.35	20.70	9.98	1.70	12.01	17.73	17.68	20.11
Jun	18.96	19.20	10.92	4.45	12.55	18.44	18.88	19.47
Jul	20.57	20.78	11.96	3.94	17.75	14.30	19.12	19.12
Aug	21.22	18.90	11.96	3.48	16.80	14.73	18.43	19.14
Sep	16.10	15.80	11.05	3.23	10.25	11.81	17.15	17.13
Oct	16.34	15.11	7.82	2.34	8.94	11.02	15.01	14.67
Nov	10.01	9.55	5.08	1.47	5.87	9.07	12.95	11.02
Dec	8.22	7.85	4.32	1.83	5.83	6.83	11.61	9.51
Total	153.63	173.52	101.63	28.51	123.23	137.13	184.62	185.65

[1] Data reported by Shih and Gascho (1980).
[2] Data reported by Clayton (1949).

consequence of this lagging problem, Shih et al (1977) demonstrated that the Thornthwaite method underestimated ET during cooling months and overestimated ET during the warming months.

A. Pan Evaporation Method: As indicated in previous section, the evaporation pan is the most widely used evaporation instrument today, and its application in hydrologic design and operation is of long standing. The relationship between ET and pan evaporation can be expressed as:

$$ET = k \cdot PE \qquad (1)$$

where k = Evapotranspiration coefficient; and
PE = Pan evaporation.

A constant k value has been commonly used by previous researchers. However, this study involved developing a matrix for k values with different months and crops types.

B. Blaney-Criddle Method: Blaney-Criddle (1950) developed a simplified formula for estimating consumptive water used in the arid western regions of the United States. This method is assumed that the heat budget is shared in fixed proportion between heating the air and evaporation. With this assumption, it is evident that consumptive use should be related to the hours of sunshine and temperature. Therefore, the seasonal ET is expressed as:

$$ET = kf$$

where k = Evapotranspiration coefficient;
f = Monthly ET factor = $2.54\ P(1.8\ Tm + 32)/100$; (3)
Tm = Mean monthly temperature (°C); and
P = Monthly mean percent of possible sunshine.

In this study, the k values were generated in a matrix form for monthly base and crop types. The P value was replaced by a most important factor affecting the pan evaporation.

Results and Discussion—When long term averages of pan evaporation data were correlated to solar radiation, percentage of sunshine, temperature and rainfall, the correlation coefficients obtained were 0.99, 0.93, 0.74, and 0.63, respectively (Table 3). These results implied that solar radiation was the most important factor affecting the evaporation on a long term basis. To observe the climatic factors affecting the evaporation on a short period basis, the daily climatic data of 1978 and 1979 were used to analyze the correlation coefficients between pan evaporation and climatic factors. The results of daily, weekly, and monthly basis are in Table 4. Some specific observations can be made from Table 4. Positive correlation coefficient value increased when the time interval increased. This means that the climatic factors with longer period records were better correlated to the pan evaporation. Solar radiation was the most important factor influencing the evaporation. The values in 1978 increased from 0.8 for daily basis to 0.94 for weekly, and 0.98 for monthly basis calculations. The correlation coefficient values in 1979 in-

TABLE 3. Correlation coefficients among climatic factors.

Climatic Factors	Rainfall	Temperature	Pan Evaporation	Solar Radiation
Temperature	0.95			
Pan Evaporation	0.63	0.74		
Solar Radiation	0.59	0.69	0.99	
% of Possible Sunshine	0.79	0.83	0.93	0.92

creased indicating a similar trend in 1978. The significant levels of testing were all done at as high as 0.01% level of probability.

Other important factors affecting the evaporation were air and soil temperatures. The correlation coefficients were not as high as with solar radiation, but they tested significant at levels up to 0.01%.

Based on the correlation coefficient, wind motion in south Florida did not appear to be an important factor influencing the evaporation process. This might support the concept of using the lysimeter study to estimate the ET loss. Use of lysimeters to study ET has been criticized for some time. The main reason is that wind motion in the lysimeter may not be similar to the field conditions.

Relative humidity and rainfall are not important factors to be considered in the evaporation study because the correlation coefficient values were low.

To investigate further the climatic factors influencing evaporation in a relative percentage basis, multiple regression analysis technique was used. The multiple regression model was developed for pan evaporation (PE) treated as a dependent variable. The independent variables are solar radiation (SR), mean air temperature (TA), wind motion at 60 cm above the ground (WL), rainfall (RF), continuous period of wetness (WC), minimum percentage of relative humidity (HM), maximum soil temperature (SH), relative humidity over 90% (HR), wind motion at 600 cm above the ground (WH), and minimum soil temperature (SL). The daily climatic data of 1978 and 1979 were used to develop the model as follows:

$$\begin{aligned} PE = {} & -0.14952 + 0.00034\ SR^{**} + 0.00134\ TA^{**} + 0.00041\ WL^{**} \\ & + 0.01615\ RF^{**} - 0.00058\ WC^{*} - 0.00049\ HM^{*} + 0.00171\ SH^{*} \\ & + 0.00046\ HR + 0.00014\ WH - 0.00073\ SL\ (R^2 = 0.77) \end{aligned} \tag{4}$$

The symbols of (**) and (*) represent the significant level of F-test at 1 and 5%, respectively. The PE was not significantly influenced by the parameters of HR, WH and SL. The other 7 parameters of SR, TA, WL, RF, WC, HM, and SH did affect significantly on the PE at least at the 5% probability level. However, the PE was influenced by SR, TA, WL, RF, WC, HM, and SH on a 68:25:5:2:0:0:0 relative percentage basis in this study. In other words, there are 7 parameters affecting on the evaporation; only solar radiation with 68% influence and temperature with 28% were considered to be the

TABLE 4. Correlation coefficients between pan evaporation and climatic factors.

	Daily Data		Weekly Data		Monthly Data	
Climatic factors	Corr. Coeff.	Sign level %	Corr. Coeff.	Sign level %	Corr. Coeff.	Sign level %
1978						
Air temp. min.	0.34	0.01	0.50	0.02	0.57	5.39
Air temp. max.	0.49	0.01	0.64	0.01	0.72	0.81
Air temp. mean	0.44	0.01	0.58	0.01	0.65	2.23
Solar radiation	0.80	0.01	0.94	0.01	0.98	0.01
Rainfall	0.02	74.33	0.19	17.05	0.51	9.05
Wind motion at 60 cm	0.04	50.12	-0.21	14.40	-0.39	21.52
Wind motion at 600 cm	0.01	87.26	-0.21	13.46	-0.38	22.47
Soil temp. min.	0.47	0.01	0.54	0.01	0.68	1.43
Soil temp. max.	0.63	0.01	0.76	0.01	0.79	0.24
Rel. humidity, 90%	-0.15	0.47	-0.19	18.18	-0.05	87.50
Rel. humidity, min. %	-0.25	0.01	-0.07	64.46	0.20	53.58
Wetness, hrs.	-0.18	0.66	-0.44	1.01	-0.59	12.22
1979						
Air temp. min.	0.30	0.01	0.44	0.12	0.53	7.74
Air temp. max.	0.50	0.01	0.64	0.01	0.70	1.09
Air temp. mean	0.42	0.01	0.54	0.01	0.62	3.27
Solar radiation	0.83	0.01	0.95	0.01	0.98	0.01
Rainfall	-0.10	6.51	0.09	53.48	0.11	73.86
Wind motion at 60 cm	0.05	32.79	-0.14	33.53	-0.26	41.75
Wind motion at 600 cm	-0.02	73.06	-0.27	4.92	-0.45	14.26
Soil temp. min.	0.51	0.01	0.66	0.01	0.71	0.92
Soil temp. max.	0.59	0.01	0.70	0.01	0.73	0.71
Rel. humidity, 90%	-0.18	0.04	-0.18	16.05	-0.17	60.66
Rel. humidity, min. %	-0.43	0.01	-0.37	0.64	-0.39	20.82
Wetness, hrs.	-0.25	0.01	-0.30	3.18	-0.30	34.17

important factors. Wind motion and rainfall showed only 5% and 2% influence, respectively. The PE influenced by the other 3 parameters of wetness, relative humidity, and soil temperature were near 0% as compared with other important factors.

Soil temperature in correlation analysis did show as an important factor influencing the PE, but the degree of importance can be neglected as shown in multiple regression analysis. Based on both correlation and multiple regression analyses, it was found that both solar radiation and air temperature were only 2 important factors influencing the evaporation in south Florida.

Modified Blaney-Criddle Method: As discussed in previous section, it can be concluded that the solar radiation and temperature are the important factors to be considered in ET estimation. Based on that, the Blaney-Criddle method as defined in Equation 3 can be modified as:

$$ET = k\,2.54\,R(1.8\,Tm + 32)/TR \qquad (5)$$

where k = Evapotranspiration coefficients;
Tm = Mean monthly temperature, °C;
R = Mean monthly solar radiation, langley units (cal/cm^2); and
TR = Annual mean monthly langley units.

Based on the value of k = 1 and the definition of monthly ET factor given in equation 2, the ET shown in equations 2 and 5 become as monthly ET factors for Blaney-Criddle method (B) and modified Blaney-Criddle method (C), respectively. The results are in Table 2. These monthly ET factors were used to establish the k values for different crops.

Evapotranspiration Coefficients: Evapotranspiration coefficients (k) were computed based on the methods of pan evaporation, Blaney-Criddle, and modified Blaney-Criddle as defined in equations 1, 2 and 5. The value of k was a function of vegetations and time. The results are in Table 5. Mean value was used to interpret the general relationship between measured and estimated ET. The standard deviation was used to observe the seasonal variation in different crop using different method for ET estimation. Some important observations can be made from Table 5. The mean k value estimated by pan evaporation method was always higher than by using other 2 methods. This implied that the evaporation estimated by both original and modified Blaney-Criddle methods was higher than that by pan evaporation method. The mean k values for vegetation varied from 0.646 to 1.094. This indicates that a constant k value cannot be applied to all types of vegetation.

The standard deviation for vegetations varied from 0.089 to 0.361; a constant k value cannot be applied for the monthly ET relation. Thus, it is obvious that the k values varied with vegetation types and time.

Both mean k values in Blaney-Criddle and modified Blaney-Criddle method are very similar to each other. But the standard deviation in modified Blaney-Criddle method was less than that in either pan evaporation method or Blaney-Criddle method. This implied that the year-round ET value estimated by the modified Blaney-Criddle approach was closer to the actual ET measurements.

The k values for November, December, January and February in Blaney-Criddle method are all less than those obtained by modified Blaney-Criddle method. This implied that the evapotranspiration computed by original method was overestimated in those months.

TABLE 5. Comparison of evapotranspiration coefficients computed from three methods of pan evaporation, Blaney-Criddle, and modified Blaney-Criddle.

	Sugarcane			Sawgrass			Bare Soil		
Month	A*	B	C	A	B	C	A	B	C
Jan	0.537	0.389	0.482	1.108	0.083	0.995	0.560	0.406	0.503
Feb	0.353	0.285	0.305	0.869	0.702	0.750	0.583	0.471	0.503
Mar	0.541	0.572	0.519	0.804	0.851	0.772	0.521	0.551	0.500
Apr	0.651	0.681	0.564	0.946	0.990	0.821	0.621	0.650	0.538
May	0.851	0.868	0.763	1.148	1.171	1.029	0.553	0.564	0.496
Jun	1.198	1.004	0.974	1.214	1.017	0.986	0.690	0.578	0.561
Jul	1.296	1.076	1.076	1.309	1.087	1.087	0.754	0.625	0.625
Aug	1.360	1.151	1.109	1.211	1.025	0.987	0.767	0.649	0.625
Sep	1.236	0.939	0.940	1.212	0.921	0.922	0.848	0.644	0.645
Oct	1.383	1.089	1.114	1.279	1.007	1.030	0.662	0.521	0.533
Nov	1.076	0.773	0.908	1.027	0.737	0.867	0.546	0.392	0.461
Dec	1.051	0.708	0.864	1.004	0.676	0.825	0.552	0.372	0.454
Mean	0.961	0.795	0.802	1.094	0.916	0.922	0.638	0.535	0.537
Std. Dev.	0.361	0.279	0.273	0.164	0.160	0.112	0.106	0.103	0.065

	Cane Trash			Alfalfa			Bahiagrass		
Month	A*	B	C	A	B	C	A	B	C
Jan	0.139	0.101	0.125	0.665	0.482	0.597	0.783	0.567	0.703
Feb	0.146	0.118	0.126	0.683	0.552	0.589	0.734	0.593	0.633
Mar	0.118	0.125	0.113	0.564	0.596	0.541	0.846	0.894	0.811
Apr	0.102	0.107	0.089	0.754	0.789	0.654	0.806	0.844	0.699
May	0.094	0.096	0.084	0.666	0.679	0.597	0.983	1.003	0.882
Jun	0.281	0.236	0.228	0.793	0.665	0.644	1.166	0.977	0.947
Jul	0.248	0.206	0.206	1.118	0.928	0.928	0.901	0.748	0.748
Aug	0.223	0.189	0.182	1.007	0.911	0.878	0.944	0.799	0.769
Sep	0.248	0.188	0.188	0.787	0.598	0.598	0.906	0.689	0.689
Oct	0.198	0.156	0.159	0.757	0.596	0.609	0.933	0.734	0.751
Nov	0.158	0.113	0.133	0.631	0.453	0.533	0.975	0.700	0.823
Dec	0.234	0.158	0.192	0.745	0.502	0.613	0.873	0.588	0.718
Mean	0.182	0.149	0.152	0.770	0.646	0.648	0.832	0.761	0.764
Std. Dev.	0.064	0.047	0.046	0.167	0.157	0.124	0.254	0.147	0.089

* A = Pan evaporation method, B = Blaney-Criddle method, C = Modified Blaney-Criddle method.

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Biological Sciences

SOME OBSERVATIONS ON THE HOLLOW CURVE OF DISTRIBUTION

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ABSTRACT: *The number of species in each extant phylum of animals is an excellent example of the hollow curve of distribution. The Arthropoda comprise 80.0% of all living animal species; and 11, or 29.7% of all animal phyla, have less than 100 living species. The 7 classes of the Mollusca are another example of the hollow curve of distribution. The Gastropoda comprise 79.6% of all living species of molluscs and are the only class found in marine, fresh water, and terrestrial habitats. The Monoplacophora are a relict group, and contrary to what Willis believed, relict groups are not rare. The 5 living classes of the Echinodermata are not a typical example of the hollow curve of distribution.*

J. C. WILLIS (1922), a botanist, first noted that when the genera of a family are tabulated as to the number of species in each genus, there will be 1 or 2 genera with many species, a few medium-sized genera, and many genera of small size, commonly monotypic. Willis thought that the large-sized genera, which commonly had the widest geographic area, were the oldest, and the genera with few or 1 species were the youngest genera. Thus, he proposed the concept of Age and Area. Willis believed that relict taxa were rare. He referred to this pattern as the hollow curve of distribution as is shown in the graphs where the number of genera are plotted against the number of species in each genus. Lotka (1956) refers to the hollow curve as a hyperbola of the generalized type, which yields a straight line when plotted logarithmically. Little has been written on this phenomenon of diversity, although it has applications to taxomony (Chamberlin, 1924, Ferris, 1928, Nicol, 1958, Blackwelder, 1967), ecology, biogeography, evolution (Willis, 1940), and paleontology. Anderson (1974) has a good recent review of this subject.

The number of species per animal phylum, which certainly exemplifies the hollow curve of distribution, was mentioned by Nicol (1958) and graphed by Anderson (1974). However, it is well to examine this example again in a somewhat different way. The data in Table 1 were taken from a previous paper (Nicol, 1979) with the phyla rearranged on the basis of the number of species in each. The number of animal phyla with less than 100 living species is 11, or 29.7% of all animal phyla. The percentage of animal phyla with less than 1,000 living species is 64.9% and only 35.1% of all animal phyla have more than 1,000 species each. The Arthropoda comprise about 80.0% of all living species of animals, although this may be reduced a little when the species of Nematoda are better known.

Contrary to the assumption of Willis (1922), many groups of animals are relicts, and these groups have their effect on graphs depicting the hollow curve of distribution. Twenty-one, or 56.8% of all the phyla of living animals, have 350 species or less, and it is possible that some of these are relicts. Of these 22 phyla, only the brachiopods have a good fossil record. In the Devonian Period, there must have been at least 2,000 living species of brachiopods at a particular time, based on the number of genera, families, and superfamilies that lived during that geologic period. If the brachiopods cannot be considered a relict phylum, it is generally agreed that they have been in a period of decline for at least the past 200 million years (Williams, 1965). I have previously pointed out (Nicol, 1977) that the Onychophora are probably a relict phylum because of the disjunct distribution of the families and genera. The Pterobranchia, with mainly an endemic distribution, also appear to be a relict phylum. Disjunct, and sometimes endemic, geographic distributions are good indicators of relict groups. Possibly the phylum Myzostomida is a relict. These strange animals are commensals or parasites mainly on crinoids, which were certainly more diverse during the Mississippian Period. A few species of the Myzostomida are parasitic on other classes of echinoderms, but the myzostomids do not have a symbiotic relationship with any other phylum of animals. The Calyssozoa or Entoprocta are possibly a relict because the phylum has few species (about 60), and yet has both marine and fresh-water species, colonial and solitary species, and

TABLE 1. The extant animal phyla arranged by the number of species in each.

Phyla	No. of species
1. Arthropoda	1,000,000
2. Mollusca	58,000
3. Nematoda	50,000
4. Vertebrata	41,700
5. Protozoa	35,000
6. Platyhelminthes	13,000
7. Coelenterata	10,000
8. Annelida	9,300
9. Echinodermata	6,000
10. Porifera	5,000
11. Bryozoa	4,000
12. Tunicata	1,600
13. Rotifera	1,500
14. Rhynchocoela	750
15. Acanthocephala	600
16. Gastrotricha	350
17. Tardigrada	350
18. Sipunculoidea	330
19. Brachiopoda	300
20. Gordiacea	230
21. Echiuroidea	150
22. Myzostomida	150
23. Ctenophora	100
24. Kinorhyncha	100
25. Pogonophora	100
26. Enteropneusta	100
27. Gnathostomulida	90
28. Onychophora	75
29. Chaetognatha	75
30. Pentastomida	70
31. Calyssozoa	60
32. Mesozoa	50
33. Cephalochordata	30
34. Phoronida	25
35. Pterobranchia	25
36. Priapuloidea	8
37. Monoblastozoa	1
Total Number of Species	1,239,219

dioecious and hermaphroditic species. Small size alone is not prima-facie evidence that a phylum is a relict. Perhaps most of these small phyla have always been small because they have been restricted to a few niches. These phyla may have physical and physiological characteristics that have restricted their diversity.

The numbers of living species in the 7 classes of molluscs nicely fit the hollow curve of distribution, but to my knowledge this has not been pointed out by malacologists. Except for the Aplacophora, the classes of molluscs have a reasonably good to excellent fossil record. Data on the number of living species of the 5 small classes of molluscs were taken from Boss (1971). A recent estimate of the number of living species of Mollusca is about 58,000 (Table 2). Of this number, the gastropods have 46,190 or 79.6% of all molluscan species. The gastropods are the only class of molluscs that are found in the seas, fresh water, and on land (Table 2). They have a wider range of feeding habits than any other class of molluscs; gastropods may be carnivores, herbivores, deposit feeders, suspension feeders, and parasites. The pelecypods live only in the seas and fresh water. Most of them are suspension feeders, but deposit feeding is quite common and parasitism is rare. Pelecypods comprise about 17.2% of all living species of molluscs. The ratio of gastropod to pelecypod species is 4.6:1. The remaining 5 classes of molluscs comprise 3.1% of all molluscan species. Moreover, the 3 smallest classes (Scaphopoda, Aplacophora, Monoplacophora) have only about 1.0% of all the species of molluscs. All 5 of these small classes are restricted to a marine environment and have only 1 or 2 modes of feeding. The Monoplacophora are a relict class, and the first living species was discovered in 1952 (McLean, 1979). The monoplacophoran species are mainly confined to the abyssal zone. The living cephalopods are commonly considered a waning group, and the subclass Nautiloidea is certainly a relict. However, as in the past, some living cephalopod species attain a large body size and, as carnivores, are near the top of the food pyramid. Because of their size and feeding habits, it is doubtful that this class has ever attained much more than 1,000 species, and the greatest diversity of the class probably was attained during the Jurassic Period. The Polyplacophora and Scaphopoda have a long geologic history, but they have shown little adaptive radiation. They have apparently always been small classes in terms of numbers of species. These 5 small classes comprise 71.4% of all classes of molluscs.

TABLE 2. The extant classes of Mollusca arranged by the number of species in each and their occurrence in marine (M.), fresh water (F.W.), and terrestrial (T.) habitats.

Classes	No. of species	M.	F.W.	T.
1. Gastropoda	46,190	X	X	X
2. Pelecypoda	10,000	X	X	
3. Cephalopoda	600	X		
4. Polyplacophora	600	X		
5. Scaphopoda	350	X		
6. Aplacophora	250	X		
7. Monoplacophora	10	X		
Total Number of Species	58,000			

Relict groups have occurred at least as far back in time as the Cambrian. The archaeocyathids were relicts by Middle Cambrian time, the graptolites by Early Mississippian time, and the trilobites and eurypterids by Permian time. In some groups the period of decline is long, but in other groups extinction soon follows the acme of diversity.

Although the sample is small, the 5 classes of living echinoderms are not a typical example of the hollow curve of distribution (Table 3). Of the approximately 6,000 living species of the Echinodermata, the Ophiuroidea have 2,000 or only 33.0%. In the previous 2 examples discussed, the Arthropoda and the Gastropoda have about 80.0% of all the species in their respective groups. The next largest class of the Echinodermata is the Asteroidea, which has 1,600 species or about 27.0% of the total. The 3 smallest classes are the Echinoidea with 14.0%, the Crinoidea with 13.0%, and the Holothuroidea with 13.0% of the total number of living species of echinoderms. If the number of species in each class of the Echinodermata was plotted logarithmically, the straight line would have a much less steep slope than would the number of species per phylum or the number of species in each molluscan class. The classes of the Echinodermata are all restricted to a marine environment and generally have only 1 or 2 modes of feeding in each class. None of the classes of the echinoderms has nearly the habitat or niche diversity of the Gastropoda. However, during the Ordovician, Silurian, and Devonian, when the echinoderms evolved many bizarre and short-lived classes, the Echinodermata may have been a much more typical example of the hollow curve of distribution.

TABLE 3. The extant classes of Echinodermata arranged by the number of species in each.

Classes	No. of species
1. Ophiuroidea	2,000
2. Asteroidea	1,600
3. Echinoidea	850
4. Crinoidea	800
5. Holothuroidea	750
Total Number of Species	6,000

I am certain that some other examples could be found that are not typical examples of the hollow curve of distribution. Perhaps a better term for the hollow curve of distribution would be Willis's Rule, and this term has been used occasionally.

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A SURVEY OF DEPOSIT-FEEDING ANIMALS

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Abstract: *About 13,500 living species of animals are deposit feeders. Deposit feeding is most common in coelomate animals, but a few species of small body size among the pseudocoelomates are also deposit feeders. Deposit feeding was probably the last of the basic types of feeding to arise in animals.*

In his discussion of nutrition in polychaetes, Barnes (1974) distinguishes between direct deposit feeders and indirect deposit feeders. Direct deposit feeders consume bottom sediments directly when the mouth is applied against the substratum, and the organic material is digested and the mineral portion egested as castings. This type of deposit feeder is most likely to leave a trace of its activities in the fossil record. Indirect deposit feeders secrete mucous, and detritus adheres to this secretion and is conveyed to the mouth by the aid of ciliated grooves. Deposit feeding of this second type tends to be more or less selective, and a record of this type of feeding would less likely be preserved as a trace fossil. Some animals are quite selective in the food placed in the mouth, and it is difficult to assess whether this type of animal is a deposit feeder. These bottom-dwelling animals are commonly referred to as detritus feeders and are not deposit feeders in the strict sense.

Although deposit feeders occur on land as well as in aquatic habitats, they are naturally excluded from a hard substrate. They are also restricted from an aquatic habitat that undergoes much wave and current action because fine organic nutriment is washed away (Purdy, 1964). Coarse sediments and high-energy marine environment exclude deposit feeders, but at the other extreme, deposit feeders are commonly absent from a habitat where too much organic material accumulates, toxic decomposition products are present, and oxygen is depleted by bacterial activity. Deposit feeding must also be confined to solitary benthic animals that move over or within a soft substrate. Certainly these physical and biological restraints are important factors in limiting the number of animal species engaged in deposit feeding.

From the information given in Table 1, one sees that only 12 of the 37 animal phyla have deposit-feeding species. This means that only 32.0% of

TABLE 1. The extant animal phyla with the number of species and the number of deposit-feeding species in each.

Phyla	No. of Species	No. of Deposit-Feeding Species
1. Protozoa	35,000	0
2. Mesozoa	50	0
3. Monoblastozoa	1	1
4. Porifera	5,000	0
5. Coelenterata	10,000	0
6. Ctenophora	100	0
7. Platyhelminthes	13,000	0
8. Rhynchocoela	750	0
9. Acanthocephala	600	0
10. Gnathostomulida	90	0
11. Rotifera	1,500	0
12. Gastrotricha	350	0
13. Kinorhyncha	100	90
14. Priapuloidea	8	0
15. Nematoda	50,000	2,000
16. Gordiacea	230	0
17. Calyssozoa	60	0
18. Bryozoa	4,000	0
19. Phoronida	25	0
20. Brachiopoda	300	0
21. Mollusca	58,000	2,000
22. Sipunculoidea	300	250
23. Echiuroidea	150	100
24. Myzostomida	150	0
25. Annelida	9,300	2,300
26. Tardigrada	350	0
27. Pentastomida	70	0
28. Onychophora	75	0
29. Arthropoda	1,000,000	5,000
30. Chaetognatha	75	0
31. Pogonophora	100	0
32. Echinodermata	6,000	1,000
33. Pterobranchia	25	0
34. Enteropneusta	100	80
35. Tunicata	1,600	150
36. Cephalochordata	30	0
37. Vertebrata	41,700	500
Species Totals	1,239,219	13,471

all the animal phyla have some deposit feeders. It is surprising that no phyla, except the enigmatic Monoblastozoa, are exclusively deposit feeders, for in most instances at least a few species of even the small phyla have some suspension feeders. Seven of the 12 animal phyla that have deposit feeders have more than 1,000 species each, and the Arthopoda, Nematoda, Mollusca, Annelida, Echinodermata, and Vertebrata are particularly large phyla whose representatives have a wide variety of feeding habits. The fact that these large phyla have deposit-feeding species is not unexpected. However, the fact that the Arthropoda have only about 5,000 deposit-feeding species is noteworthy. Deposit feeding seems to be confined to a few species of aquatic insects and Crustacea. Some large phyla, such as the Protozoa, Porifera, Coelenterata, and Platyhelminthes, do not have any deposit-feeding species. One sees that these 4 phyla are considered structurally primitive; they have no coelom, and if they have a gut, as in the Coelenterata and Platyhelminthes, it lacks an anus. Except for the Monoblastozoa with only 1 species, 2 phyla with deposit-feeding species, the Kinorhyncha and Nematoda, are pseudocoelomates, and the remaining 9 phyla are coelomates. The Kinorhyncha are tiny animals that attain a length of less than 1.0 mm., and it is likely that all deposit–feeding nematodes are also of small body size. It may well be that a coelom is necessary for efficient handling of detritus in the gut of a larger than microscopic animal, and a coelom aids an animal in burrowing through soft sediments (Valentine, 1973).

Suspension feeding is much more common than deposit feeding in living animal species. Only 16 phyla lack suspension-feeding species (Nicol, 1979), whereas 25 phyla lack deposit-feeding species. The estimated number of living suspension-feeding species is 40,000 compared to about 13,500 species of deposit feeders. Because some deposit feeders are either terrestrial or fresh water, the number of marine species of deposit feeders is probably about 10,000. Unlike deposit feeding, suspension feeding occurs in primitive phyla such as the Protozoa, Porifera, and Coelenterata, and from this present distribution, it appears that suspension feeders arose before deposit feeders in the animal kingdom.

It is likely that deposit feeding was the latest mode of feeding that evolved amongst the multicellular animals. This mode of feeding appears to occur mainly in living animals with a gut with both mouth and anus (an exception is the Ophiuroidea) and a coelom, which assists in burrowing. Because of these morphological restrictions, trace fossils that indicate feeding traces must appear late in the Precambrian time or not until the Cambrian. This is borne out by the fossil record (Stanley, 1976). Probably the oldest fossil traces that indicate deposit feeding were made by some species of the Annelida, although it is possible that some extinct phylum of soft-bodied animals that had a coelom may have antedated the first annelid deposit feeders. Thayer (1979) has a review of the geological occurrence of deposit feeders.

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VARIATION IN NUMBER OF PLANTAR TUBERCLES IN *PEROMYSCUS FLORIDANUS*—*I. Jack Stout and Mary H. Keim*, Department of Biological Sciences, University of Central Florida, Orlando, Florida 32816.

ABSTRACT: *Variation in plantar tubercles of* Peromyscus floridanus *was reported. The typical number was 5 per hind foot; however, the number present may range from 3-6. A tendency was demonstrated for an additional pad to be present on mice of sand-pine-scrub habitats. The additional pad may be adaptive where climbing is advantageous.*

THE Florida mouse *(Peromyscus floridanus)*, in contrast with other members of the genus, typically has 5 rather than 6 plantar tubercles (Osgood, 1909). This characteristic is diagnostic of the subgenus *Podomys* (Hall and Kelson, 1959).

Layne (1970) observed interpopulation variation in the number of plantar tubercles of *P. floridanus*. Smith (1967) and Keim (1979) discovered some individuals of *P. polionotus* have 5 plantar tubercles, rather than 6, and might be confused with *floridanus* using that character alone.

In studies of *P. floridanus* over the last 7 yr we have observed spatial and temporal variations in occurrence of plantar tubercles.

Long-term grid sampling of *P. floridanus* in sand-pine-scrub communities on the campus of the University of Central Florida in Orange County (T225, R37E, S12) provided evidence of variation in counts of plantar tubercles among years (Stout, 1976). Additional observations were made on a *floridanus* population in a xeric flatwoods habitat on Merritt Island during 1976-77 (Stout, 1979).

Counts of plantar tubercles were made on all specimens of *P. floridanus* in the collections of the Florida State Museum. Observations were made with a dissecting stereoscope.

Plantar tubercles vary in size, shape, and pigmentation (Smith, 1967; Layne, 1970). We counted pads on living animals as being present when they were visible to the unaided eye and discernable by touch. In the following account, pad counts are given for the right and left hind feet, for example, 5:5 = 5 pads on the right and 5 on the left foot.

Counts of hind foot pads on museum specimens yielded the following results: 67 of 71 (94.4%) of the individuals from Alachua (n = 6), Marion (n = 2), Palm Beach (n = 5), Pinellas (n = 7), Highlands (n = 8), Levy (n = 5), St. Johns (n = 2), Taylor (n = 8), and Putnam (n = 24) counties had 5:5. Two individuals from Alachua County had counts of 4:4 and 3:3. One specimen from Pinellas County had a count of 5:4 and another 4:4. Thus, approximately 95% of the specimens were typical in that 5 plantar tubercles were present on the hind feet.

Layne (1970) found 12 (20%) of 40 *floridanus* from Levy County to possess a 6th plantar tubercle on the hind foot, whereas none from Alachua County (n = 12) deviated from the 5:5 pattern. This variation was not reflected in the museum sample.

Variation in plantar tubercle counts on 162 individual *floridanus* from northeastern Orange County is summarized in Table 1. Eighty percent of the individuals observed over the 5-yr period conformed to the 5:5 count. Another 17% had 6 pads on each hind foot and the remainder either a reduced number (4:4) or an uneven number (5:6). The proportion of the population having typical (5:5) and exceptional numbers of plantar tubercles varied among years, but not significantly ($p > 0.05$) according to a Chi-square test of independence.

TABLE 1. Variation in number of plantar tubercles on hind feet of *Peromyscus floridanus* from the University of Central Florida sand pine scrub, 1973-77.

		Percent of Individuals with Various Number of Tubercles			
Year	n	4:4	5:5	6:6	5:6
1973	25	0.0	92.0	8.0	0.0
1974	77	1.3	75.3	20.7	2.6
1975	32	0.0	87.5	12.5	0.0
1976	9	0.0	88.8	11.1	0.0
1977	19	5.2	68.4	26.3	0.0
Totals	162	1.2	80.2	17.3	1.2

All *floridanus* (n = 10) examined from Merritt Island, Brevard County, had typical (5:5) number of plantar tubercles.

DISCUSSION—Layne (1970) has interpreted the tendency for some populations of *floridanus* to have slightly better-developed plantar tubercles in the context of selective pressures which favor climbing ability. He concluded that individuals in sand-pine-scrub communities with additional tubercles may be more efficient in climbing to secure food, e.g., acorns on scrub oaks (*Quercus* spp.). Our evidence supports his argument. The proportions of the populations from sand-pine-scrub habitats with additional tubercles (6:6) were similar (Levy County 20% vs. Orange County 18%). Further, congruence was found between typical counts (5:5) and turkey oak-pine habitat in Alachua County and xeric flatwoods in Brevard County. Neither of these habitat types offered much opportunity for climbing to be adaptive.

In summary, most individual *floridanus*, 80% or more, have 5 plantar tubercles on their hind feet. The number of pads present may vary among individuals from 3 to 6; uneven counts rarely may be observed. The tendency for additional pads to be present appears to be related to habitats where climbing ability may be advantageous. Unambiguous identificaiton of *floridanus* in the field may be based on a combination of 2 characters: 5 plantar tubercles on the hind feet and a hind foot length of $\geq$ 24 mm.

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FLORIDA SCIENTIST

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Engineering Sciences

PLANNING FOR THE MANAGEMENT OF HAZARDOUS WASTES

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ABSTRACT: *The elements of a hazardous waste management program are outlined and discussed relative to a lightly industralized region in Florida. Several factors are included such as recognition and quantification of the problem, choosing a management approach, definition of treatment/disposal methods, consideration of environmental impacts, creation of emergency reaction teams, and providing for monitoring and enforcement. Hazardous wastes may result not only from large industries, but also from small businesses from the transportation, health care, research, and consumer sectors of the economy. As a group, these other sources may contribute significantly to a region's overall hazardous waste problem. Any program for managing hazardous wastes must recognize the greatly diverse and complex nature of the problem.*

HAZARDOUS WASTES include toxic chemicals, oxidizing agents, acids and bases, radioactive isotopes, and flammable chemicals. Hazardous wastes may result from accidental spills or from intentional, low level discharges; they may be generated by manufacturers, transporters, users, or disposers of products. Because of the above considerations, almost any area of the country has a potential hazardous waste problem. Any program for managing hazardous waste must recognize the greatly diverse and complex nature of the probem.

This study results from a review of the literature and first hand interviews of various representatives of government agencies and private industries within the study area—a lightly industrialized area in Central Florida. Herein, I briefly outline some of the industrial characteristics of the study area, and identify some of the sources and types of hazardous wastes in this area. Steps required to establish a general hazardous wastes management program for this type of area are discussed.

BACKGROUND—The hazards of certain materials were recognized as early as 2000 yr ago when Pliny the Elder recommended wearing a filter mask while working with mercury and lead ores (Sax, 1975). Historically, however, emphasis has been placed on the occupational dangers of hazardous materials. Little attention has been given to the disposal of nonradioactive hazardous wastes because of small quantities and low concentrations involved. Presumably, the low concentrations helped to mask effects for many years, which was a major factor in delaying efforts to control the disposal of these wastes. Recently, there has been much interest in hazardous waste control, spurred by an increasing number of incidents, involving latent effects of improper disposal (House Report 94-1491, 1976; Ricci, 1976). The history of the main Federal laws relating to control of toxic pollutants in water has been reviewed elsewhere (Barrett, 1978).

Hazardous wastes include toxic chemicals (such as insecticides), acids (such as sulfuric acid), explosives, pathogens, and radioactive isotopes. Nonradioactive hazardous wastes have been estimated to be generated in the U.S. at the rate of about 10 million tons (9×10^9 kg) per year or about 10% of all industrial wastes (Lehman, 1974). Hazardous wastes are generated principally by industry, and thus the main objectives of Federal regulation of hazardous wastes are industrial generators, transporters and disposers (Parkinson, 1978). However, a considerable amount of hazardous materials may be generated by consumers as well (Ottinger et al., 1973). Consumer wastes, as well as any wastes from the many small commercial firms that utilize municipal sewage treatment, have been and may continue to be esentially unregulated. These wastes will almost assuredly end up in ordinary landfills.

Study Area—The East Central Florida Region (ECFR), a six-county, geopolitical planning region (see Fig. 1), was studied with regard to treatment and disposal of hazardous wastes. The ECFR contains about 16,835 square km and a population of about 1,150,000. According to Bradley (1970), the meteorology is favorable for the dispersion of air pollution with relatively high mixing heights and prevailing easterly winds. The hydrology of the region is extremely important and is a key factor in understanding the potential impacts of a hazardous waste disposal in the region. Lichtler (1972) emphasizes the importance of the region's underground water resources (which account for 99% of the total resources of the region). The region is underlain by an extensive limestone aquifer which interconnects with surface waters at many points and provides drinking water for over 90% of the population of the region as well as irrigation and industrial supplies. Although there is some drainage of the flat topography by surface waters, the vast majority is by underground drainage (Lichtler, 1972).

*Industrial Characteristics:*Manufacturing accounts for about 12% of the employment in the ECFR (East Central Regional Planning Council, 1977). Agriculture (principally citrus) and tourism are key factors in the region's economy. Primarily, the industries are food processing, electronics, aerospace, and metal plating. There are numerous smaller concerns such as distributors, resellers, and independent jobbers. Also, there are over 2000

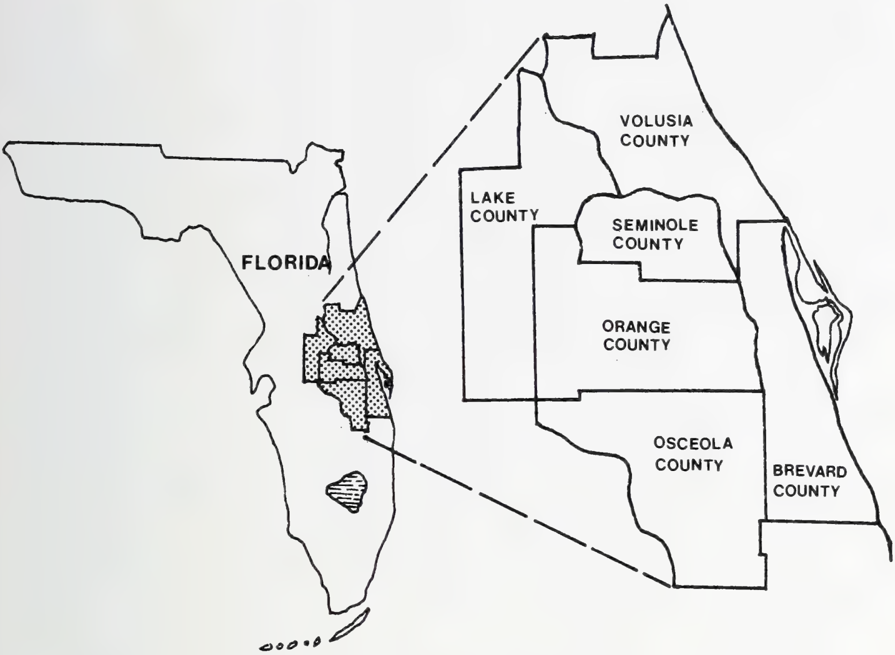

Fig. 1. Location of the study area.

MW of installed electricity generating capacity in the region (no coal or nuclear plants).

It was found that the wastes of most concern in the ECFR are heavy metals such as chromium and lead and stable organics such as certain pesticides. The large industries that were surveyed all practice on-site treatment, with disposal of the effluent to perc ponds and sludges to the land. Many of the smaller processing industies and almost all of the distributors discharge liquid wastes to municipal sewage treatment plants (STP). Most of the time there is a certain degree of pre-treatment prior to discharge to the sewers. According to the draft area 208 plan (ECFRPC, 1978), there are over 200 STP in the metropolitan Orlando area alone with a total design capacity of 93 million gallons per day (mgd). Of this capacity, 21 mgd is the design flow reserved for industrial plants. In over 90% of all cases, STP effluent is to perc ponds and sludges to landfills. Solid wastes, with but very few exceptions, are picked up by commercial firms and dumped in nearby sanitary landfills or are buried on-site. Small amounts of hazardous wastes are also generated by consumers, such as oils, partially empty paint cans, and these invariably end up in STP's or in landfills.

Certain wastes are not treated effectively in an STP; others are concentrated in the sludge and may leach out at a later date. Although this research project did not include provisions for a sampling and testing program, 3 samples from the UCF wastewater treatment plant were analyzed. Because of the small number of samples and possible errors in the absolute values of certain elements measured, the data are not reported here. However, it was clear that the elements Zn, As, Cd, Cu, Pb, and Cr were present and were being concentrated in the sludge by factors of 50 to 1000 times. If similar concentration is occurring elsewhere within the region (and there is no reason to doubt that it is), then land disposal of sludges from STP's may represent a major concern for a hazardous waste management program.

Regulatory Agencies: Regulatory agencies with jurisdiction in the ECFR include federal, state, county, and city level agencies. Florida has a regional office of its Department of Environmental Regulation (DER) located in Orlando, and each county (except one) has a pollution control department. Typically, those agencies which presently perform permitting, monitoring, and enforcement functions for conventional (BOD, SS, N, P) pollution sources are also being given responsibility for hazardous wastes. At the federal and state level, separate branches have been established to regulate hazardous wastes as mandated by law (PL 94-580, 1976). There is considerable overlap of responsibilities at present but there is also the opportunity to establish procedures for cooperation and coordination in administering a hazardous wastes program.

ELEMENTS OF A HAZARDOUS WASTES MANAGEMENT PROGRAM—The proper management of hazardous wastes is currently an extremely active field and much has been published on this topic (Fields and Lindsey, 1975; Kovalick, 1977; Lehman, 1974; Parkinson, 1978). Federal and state laws have been passed and regulatory programs have been established. But, because the management of hazardous wastes is still such a new and developing area, no one yet knows how effective the various approaches will be. It appears, however, there are certain factors or steps which should be included in any program to promote effectiveness. These factors are: recognition of the problem, definition of the problem, establishing a management approach, establishing specific procedures and facilities, ensuring environmental impact assessment planning, providing for agency-industry and interagency coordination/cooperation, ensuring monitoring, enforcement and follow-up, and providing for the flexibility to change the program to meet changing needs.

Recognition of the Problem: Recognition of the problem in a general sense is much more widespread today than it was just a few years ago. However, in possibly many areas there exists a hazardous waste problem which is not recognized because it is not yet to a crisis stage. Also, because of the difficulties or potential costs involved, people in some areas of the country may not want to acknowledge a problem which they suspect is present (Business Week, 1976). It is probably safe to say that in any area of the country in which there is any significant concentration of people, there exists a potential hazardous waste problem. A problem may not presently be manifesting itself, but as has been shown from past experience, many years may elapse before the overt effects of improper hazardous waste management are seen (House Report 94-1491, 1976). Florida has established a hazardous wastes branch in its DER. Orange County has a very active Pollution Control Department which has formally assigned responsibility for hazardous wastes to one individual. Other counties in the area have also recognized that a problem may exist.

Definition of the Problem: Definition of the problem is an even more demanding task than recognition. Definition of a hazardous waste problem for an area implies knowledge of the types, quantities, and locations of all hazardous wastes in the area, as well as the present methods of disposal and resulting effects on the environment. Under PL 94-580, EPA is required to "identify which wastes are hazardous and in what quantity, quality, concentration and forms of disposal they may become a threat to the environment" (PL 94-580, 1976). This appears to be a Herculean task for the EPA, and in the opinion of the author, local inputs must be utilized for most of this work. In addition to knowledge of the waste themselves, it is vital to know the source of each waste. Whether the wastes are primarily coming from the manufacturers, transporters, users, or disposers makes a considerable difference in devising control measures. A state-wide industrial hazardous waste survey has been completed (Herndon et al, 1977), and other work is continuing in this area.

Establishing a Management Approach: Establishing a management approach is akin to setting up a philosophical framework or planning the overall attack. Hazardous waste management means "more than careful disposal. It implies considerations of alternate methods and schemes . . . " (Kovalick, 1977). It means making policy decisions as to the type and amount of regulations to be developed. It also means establishing a hierarchy of waste management options within real-world constraints. The present DER hierarchical structure for handling hazardous wastes (Collins, 1978) appears to be quite realistic in recognizing budgetary, manpower, and facility limitations: 1) Return to economic use (trade, sell, give away to a potential user of the material); 2) Return to Sender (recycle to basic manufacturer); 3) Render innocuous (chemical neutralization); 4) Ship to a proper disposal point (a chemical landfill or waste processor); 5) Pretreatment prior to ordinary landfill. In addition to the above options, waste separation and/or concentration, and energy/material recovery should also be considered in the hierarchy while establishing an approach. At present, it appears that the counties are relying on the State to varying degrees for guidance in this area.

Establishing Specific Procedures and Facilities—Establishing specific procedures and facilities is often considered as two distinguishable steps. Procedures such as a permit system for operating a hazardous waste landfill, or a manifest system for regulating the flow of hazardous wastes must be specified. Zoning and other land use controls are potentially a very powerful means of control. In addition, certain new facilities may be required. For example, at present, there are no approved public chemical landfills or incinerators in the East Central Florida area, hence hazardous wastes are finding their way to ordinary landfills. It might even be desirable to establish waste collection points for consumers to bring small quantities of hazardous materials, especially if user-type wastes are a major problem in a given area. The economics of specific waste disposal alternatives must be carefully evaluated on a case-by-case basis. Economy of scale and better control of final disposal points associated with a large centralized processing facility may make such a facility more attractive than operating numerous treatment and disposal plants in the region of interest. On the other hand, perhaps the most cost-effective program would involve transporting wastes out of the region to a better suited area for disposal.

It is advisable to form an emergency reaction team for responding to spills, fires, and other accidents involving hazardous material. Such a team exists in the city of Jacksonville, Florida, composed of city firefighters. The team is well trained and has recently demonstrated their abilities in an incident in a small town in the Florida panhandle. Such a team is under consideration by Orange County and the City of Orlando personnel.

Environmental Impact Assessments: In the planning for procedures and facilities, proper consideration of all interacting factors must be made. An environmental impact assessment approach ensures complete coverage of all factors and has the added advantage of quantifying the economic cost of various alternatives as well as the social and environmental costs. Values must be assigned to the potential risks and benefits. While decisions should be made at the state level, local inputs must be considered in the decision making process. The methodology used should provide for consistency and repeatibility of answers.

Interagency Coordination: In any hazardous waste management program, good coordination and cooperation between federal, state, regional, and local agencies is a must. It may well be possible to utilize existing agencies at the local level with supplementary funds from the state or federal level. Orange County has a well-organized Pollution Control Department that would appear capable of handling a comprehensive hazardous waste program on a regional basis. Also, there must be cooperation between industry and the various agencies involved. This not only means timely responses by industry but also understanding on the part of the agencies and minimizing duplicative requirements.

Ensuring Monitoring, Enforcement, and Follow-up: Experience with recent environmental protection programs has shown that adequate provisions must be made for monitoring, reporting, follow-up, and enforcement. In establishing a program, these areas must be considered in the budgetary process. Herein lies a good opportunity for utilizing local personnel and not duplicating their functions with the state and/or federal employees. There probably will be some overlap, but good lines of communication will keep the costs to a minimum.

Providing for Flexibility—The flexibility to change the program as the needs of the area change is a highly desirable characteristic. Flexibility is often difficult to achieve within the context provided by regulations written in "legalese". However, just because achieving flexibility may be difficult is not a reason to abandon it as a goal. In many cases, there is no substitute for relying on "good engineering judgment" rather than adhering to a fixed set of procedures. It must be recognized that some treatment is better than none, and in some cases, a "hard-line" approach may result in clandestine dumping and thus no treatment.

SUMMARY AND CONCLUSIONS—A lightly industrialized area can have a hazardous waste disposal problem as well as a heavily industrialized area. The sources and type of hazardous wastes, and their impacts on the environment differ for different geographical locations. Although the specific methods of solving a particular area's hazardous wastes problem will differ from case to case, the planning involved in establishing a hazardous waste management program will involve the same elements.

Hazardous waste management is a rapidly expanding field. Innovative answers are required to some very difficult problems. Establishing an effective program to manage the generation, handling, treatment, and disposal of hazardous wastes within a region involves the consideration of many factors. In the final analysis, the management of hazardous wastes is similar to other management problems. It involves balancing economic and environmental costs, human and material resources, and taking risks over a period of time in order to best achieve certain objectives. The main differences lie in the fact that when dealing with hazardous wastes all of the above parameters exist on a much larger scale than with traditional management problems.

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Environmental Sciences

SELECTED TRACE METALS IN THE UPPER ST. JOHNS RIVER AND THEIR LAND USE RELATIONSHIPS

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Abstract: *Iron, copper and zinc were monitored in the water, sediments, and 4 species of fish of the upper St. Johns River, Florida. Surface water concentrations of total iron commonly exceeded 300 ug/l, the standard established by the Florida Department of Environmental Regulation for waters intended for public consumption (Class I waters). Total iron levels in the upper St. Johns River are regulated by a series of interacting natural processes such as the iron-phosphate cycle, inputs from nonartesian groundwater or bank seepage, complexation with dissolved organic compounds, increased land runoff during perids of high flow, and resuspension of bottom sediments during periods of increased discharge or wind mixing. Groundwater inputs in the headwaters region due to agricultural irrigation practices, in addition to runoff and groundwater seepage into the drainage canals entering the river, have significantly increased its trace metal content. Elevated trace metal levels were also found in sediments and fish tissue in the river. The results of multiple regression analyses indicated that as the extent of urban activity increases in undeveloped watersheds of the upper St. Johns River, total copper and total zinc concentrations in the surface waters of the watershed can also be expected to increase.*

Metal Concentrations have been shown to be increasing in many aquatic systems as a result of accelerated urban, agricultural, or industrial development (MacKereth, 1965; Shimp, Leland, and White, 1970; Collinson and Shimp, 1972; Pita and Hyne, 1975; Haith, 1976). Bedient et al. (1975), studying the upper St. Johns River Basin, Florida, emphasized that future research efforts should be aimed at gathering more information on the hydrological and ecological responses to changes in land use and vegetation.

The upper St. Johns River basin has undergone rapid agricultural development and urbanization in recent years, which has affected the water quality and reduced the storage capacity of the river and marsh. Historical data indicate that levels of dissolved solids, trace metals and various mineral components have been gradually increasing (Mason and Belanger, 1979). The upper St. Johns River basin, however, represents a valuable resource to Brevard County due to its role as a focal point for recreation and fishing and as the drinking water source (Lake Washington) for South Brevard County. Careful watershed management practices appear to be needed for the protection of this resource.

In this study, iron, copper, and zinc were monitored in 4 species of fish, in the water and in the sediments of the upper St. Johns River in order to evaluate land use-water quality relationships. Additional objectives of the research included evaluations of the role of natural interacting processes in regulating surface water trace metal concentrations, the accumulation of trace metals in bottom sediments and fish tissue, the relationships between fish weight and total length and trace metal levels in the muscle, gills, and liver, and the relationship between volatile solids (organic matter) and trace metal concentrations in the sediments.

Description of Study Area—The St. Johns River emerges from a dense marsh in east-central Florida and flows 418 km northward to Jacksonville where it empties into the Atlantic Ocean. The river, the southern third of which is fresh water, flows through an extensive marsh floodplain and a number of shallow fresh water lakes, including Lakes Helen Blazes, Sawgrass, Washington, Winder and Poinsett, which are located in Brevard County (Fig. 1). The broad floodplains along both sides of the river are due to the flat topography and resulting slow drainage. The climate of the region is humid subtropical. The average annual temperature of the area is 22°C and the average annual rainfall is approximately 143.3 cm. More than 50% of the yearly precipitation falls from June through August as short term showers and thunderstorms, resulting in high flow rates in the summer and early fall. The flat topography and paucity of rainfall in the winter and spring, however, result in extremely slow flow rates during those months. Hydrologic considerations of the upper St. Johns River basin are discussed by McElroy (1977).

Methods—Surface water samples from 42 stations in the upper St. Johns River in watersheds SJ-1 (headwater region above Lake Helen Blazes), SJ-2 (Lake Helen Blazes and Lake Sawgrass), SJ-3 (Lake Washington), and SJ-5 (Lake Poinsett) were periodically monitored for total iron, total copper, and total zinc from April through September, 1978 (Fig. 2). Samples were collected in acid-washed glass bottles at a depth of 0.3 m.

Analyses were also conducted on 3 samples from deep (artesian) wells near Lake Washington and on 1 nonartesian groundwater sample. Analytical procedures for determining total metal concentration were performed according to techniques described in *Standard Methods* using a Jarrel-Ash MVAA atomic absorption spectrophotometer (A.P.H.A., 1975).

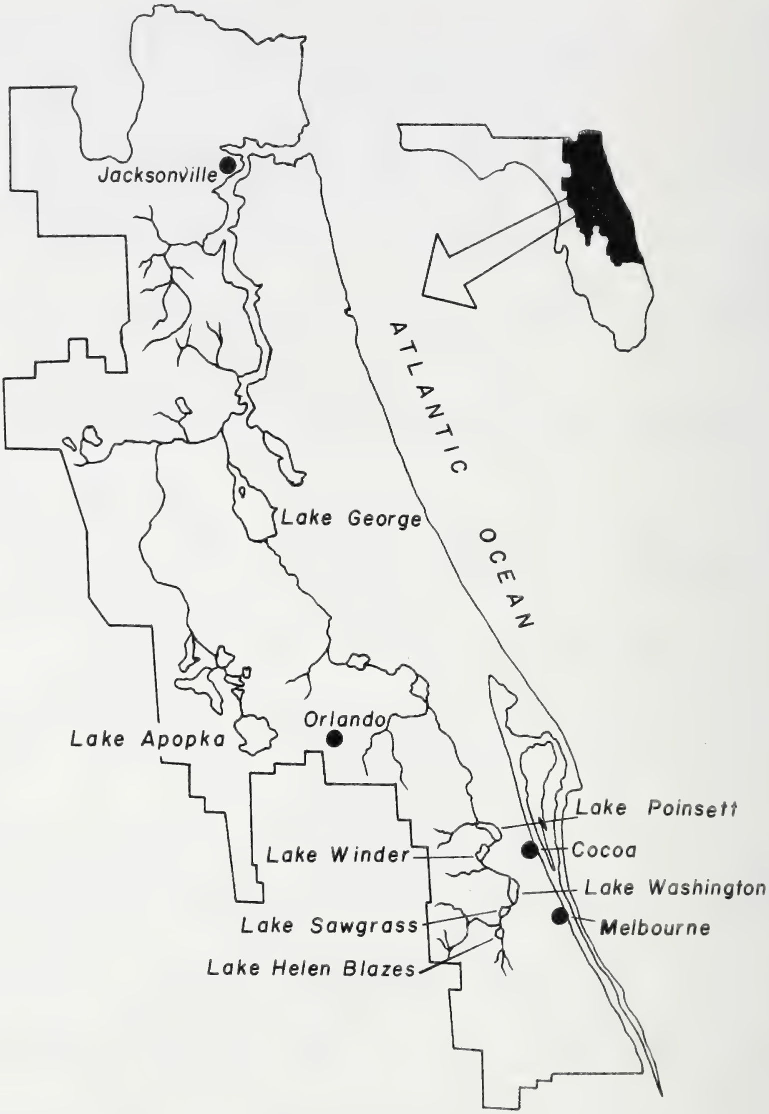

Fig. 1. St. Johns River basin.

Sediment cores were collected in plexiglass tubes (3.8 cm inner dia.) at 26 selected sites within each of the 4 watersheds. A one-gram portion of each air-dried sediment subsample was accurately weighed and transferred into a 125 ml florence flask for digestion. The sample was digested using the acid digestion procedure described by Chernoff (1975). The digested solution was cooled for 15 min and filtered to remove silicates and other insoluble material which could clog the atomizer of the atomic absorption unit. Per-

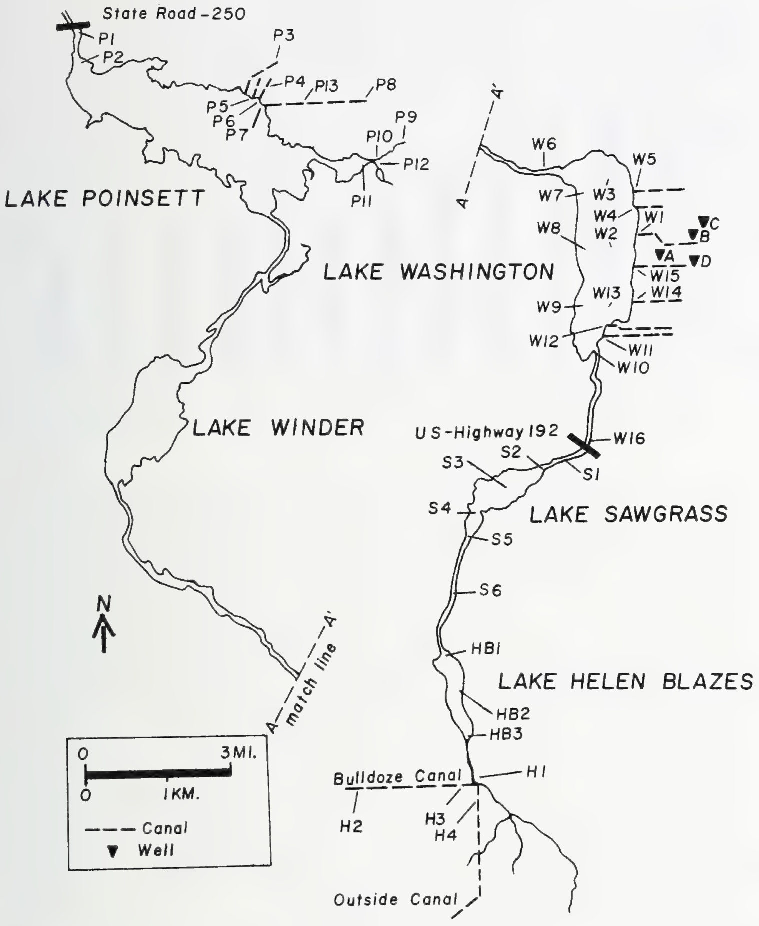

Fig. 2. Sampling stations.

cent organic composition of the sediments was estimated by measuring volatile solids lost upon ignition in a muffle furnace at 550° ± 50°C (A.P.H.A., 1975).

Forty-nine fish, including largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), speckled perch (*Pomoxis nigromaculatus*), and eastern chubsucker (*Erimyzon succetta*), were collected in February, 1978, using an electroshocking technique under the supervision of the Florida Game and Fresh Water Fish Commission. Fish were also collected during a fish kill in August 1978, caused by low dissolved oxygen levels. After collection, the fish were brought to the laboratory where weight and total length measurements were made. Axial muscle, gill tissue, and liver tissue were dissected from each fish and digested using the Chernoff (1975) procedure. Because complete digestion of fatty acids was not accomplished dur-

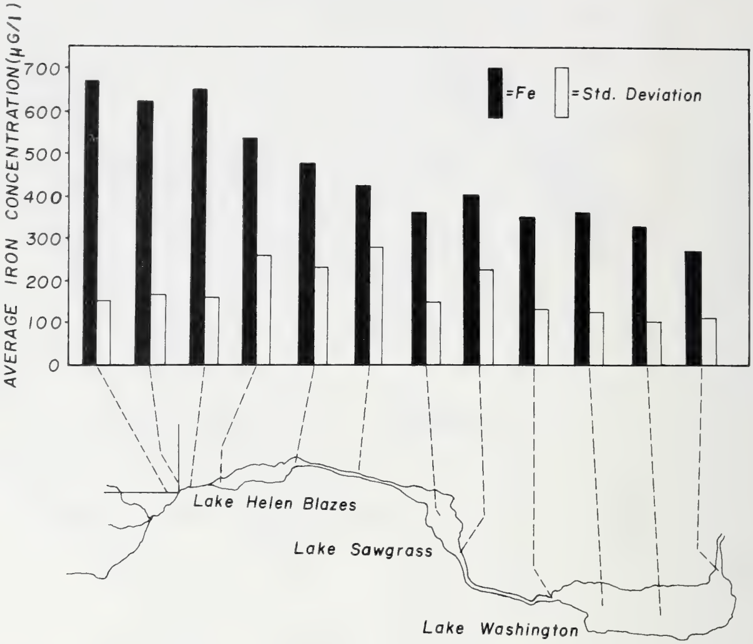

Fig. 3. Average surface water total iron concentrations at selected sites in the upper St. Johns River.

ing the digestion procedure, the fatty acids were separated in an organic phase using n-amyl alcohol to prevent clogging of the aspirator tube on the atomic absorption spectrophotometer. Water, sediment, and fish tissue samples, including spikes, were analyzed in duplicate or triplicate to evaluate precision and reproducibility of results.

Results and Discussion—Mean surface water concentrations of total iron monitored at selected sites in the upper St. Johns River are in Fig. 3. Although total copper and total zinc were present in low concentrations in the surface waters, total iron levels frequently exceeded the state standard of 300 ug/l for Class I waters. Surface water concentrations of total copper varied from less than detection limits to 15 ug/l, while total zinc levels ranged from 8 to 58 ug/l throughout the basin. Highest average concentrations of total iron (> 600 ug/l) were measured in watershed SJ-1, the headwaters region of the upper St. Johns River, and decreased in a northward direction to Lake Washington. Groundwater inputs in the headwaters region, due largely to wells and irrigation practices on large cattle and citrus farms in the area, appear to be responsible for increased levels of total iron in the surface waters. The highest concentrations of total copper and total zinc, however, were measured in the surface waters of the Lake Washington and Lake Poinsett watersheds.

The impact of canal systems upon the surface water trace metal content

TABLE 1. Average trace metal concentrations in drainage canals of Lake Washington.

Sampling Site	Samples Analyzed	Metal Concentrations (ug/l) Total Iron Average	Total Iron Range	Total Copper Average	Total Copper Range	Total Zinc Average	Total Zinc Range
Canal W1	11	333	86-1140	3	ND-12	18	5-35
Canal W4	8	319	133- 570	7	ND-22	10	ND-17
Canal W5	9	330	228- 469	8	ND-22	13	4-18
Canal W11	8	397	177- 768	4	ND-22	13	4-18
Canal W12	8	386	141- 756	3	ND-22	13	4-20
Canal W14	8	322	149- 507	2	ND-12	19	ND-77
Canal W15	8	248	106- 424	6	ND-29	17	ND-34
Midlake	16	314	113- 613	2	ND-12	11	ND-18

ND = not detectable.

of the upper St. Johns River is well-pronounced within the Lake Washington watershed (SJ-3). Average surface water concentrations of trace metals monitored in the drainage canals of Lake Washington are compared to average mid-lake concentrations in Table 1. High levels of trace metals were also observed in the Lake Poinsett canal system. It appears that groundwater seepage and runoff into these canals, which to varying degrees drain residential and commercial areas, are responsible for adding increased levels of trace metals to the surface waters. Findings by Connor (1979) indicated high bank seepage rates in the canals of the upper St. Johns River and support this conclusion.

Results of analyses completed on a limited number of artesian and nonartesian groundwater samples indicate the total iron concentrations from deep (artesian) wells were generally lower than surface water levels. Nonartesian groundwater, however, is often very high in iron and consequently iron contributions from bank seepage may be very significant, particularly in the steeply sloping canals which can intercept nonartesian groundwater flow. Brown et al., (1962) reported iron concentrations as high as 4000 ug/l in nonartesian groundwater samples from the area. Similar results were found during this investigation as an iron concentration of 4550 ug/l was measured in a 7.6 m nonartesian well near Lake Washington.

In addition to groundwater inputs, levels of total iron in the surface waters also appear to be regulated by complex interactions of naturally occurring processes. Although the lakes in the upper St. Johns River are too shallow to undergo stable stratification and frequent oxygen depletion, the results of laboratory and field experimentation by Goolsby and McPherson (1970) indicate that iron-phosphate cycle interactions could dominate under conditions of low oxygen and pH. Dissolved organic compounds, predominantly fulvic acids characteristic of the highly colored waters of the upper St. Johns River, are responsible for keeping metallic ions in solution through complexation reactions.

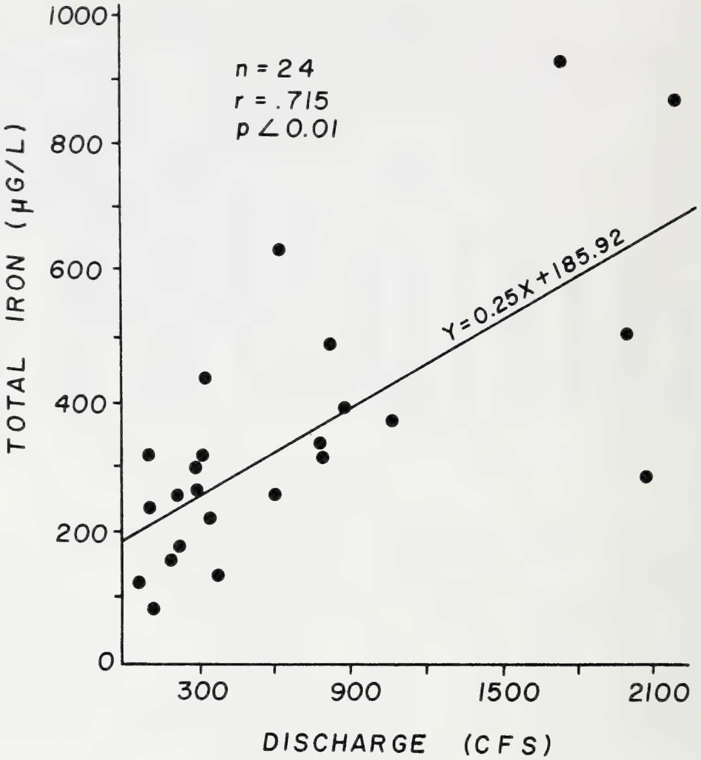

Fig. 4. Total iron concentrations in surface waters of upper St. Johns River as a function of discharge at gaging stations near Melbourne and Cocoa, Florida.

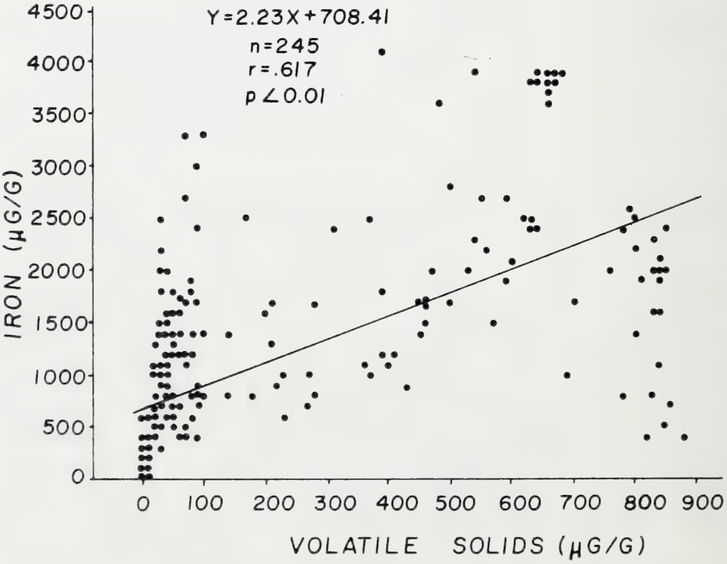

Fig. 5. Relationship of iron to sediment volatile solids.

Increased turbulence, caused by wind/wave action, outboard motors, or increased flow, may also be responsible for increasing total metal concentrations in the surface waters as a result of sediment disturbance and resuspension in the overlying water column. Using data collected by the United States Geological Survey (1976) for gaging stations located on the St. Johns River at US Highway 192 near Melbourne and State Road 520 near Cocoa, the relationship between discharge and total iron concentrations was verified. These data, shown graphically in Fig. 4, were highly significant ($p<0.01$) and demonstrate that total iron concentrations can be expected to increase linearly as a function of increasing discharge. Because total copper and total zinc have not been monitored routinely prior to this study, no attempt was made to correlate either of these variables with discharge.

The sediments of the upper St. Johns River vary in composition from sandy soils to organic-muck soils. Sandy sediments generally contained less than 10% volatile solids, whereas organic soils consisted of as much as 86% volatile solids. In these sediments, copper concentrations varied from less than detection limits to 25.1 ug/g, while zinc levels ranged from 1.2 to 212.2 ug/g. Iron reached a maximum concentration of 4090 ug/g at the mid-lake station in Lake Washington, where organic-muck sediments were encountered.

Linear regression analyses were performed to determine whether sediment levels of iron, copper, and zinc were correlated with organic matter (volatile solids). These results, shown in Figs. 5 through 7, demonstrate that as the volatile solids content of the sediment increases, the concentrations of trace metals can also be expected to increase. These results suggest that organic and humic substances deposited in marsh sediments during deposition and decomposition of vegetation complex with metal ions, thus the accumulation of metals in the sediments.

Mean concentrations of iron, copper, and zinc in fish from the upper St. Johns River are in Table 2. These results indicate that trace metals are selectively concentrated within fish liver, while lower concentrations are found in the gills and the lowest levels are found in muscle. Exceptions to this trend were higher average copper and zinc concentrations in the gills of speckled perch and bluegill, respectively.

Linear regression analyses were performed on the data to evaluate the relationships between fish weight and total length and corresponding trace metal tissue concentrations. Because only 3 speckled perch and eastern chubsucker were analyzed, statistical tests were not performed on these data. Results of these tests indicated that iron accumulates within the liver of largemouth bass as a function of increasing body length. The regression, improved by using a coefficient of condition which incorporates total length and weight measurements into one variable, suggests that largemouth bass accumulate iron through time, with longer, heavier fish containing higher levels of iron in the liver. This relationship is shown in Fig. 8 and is expressed by the following equation:

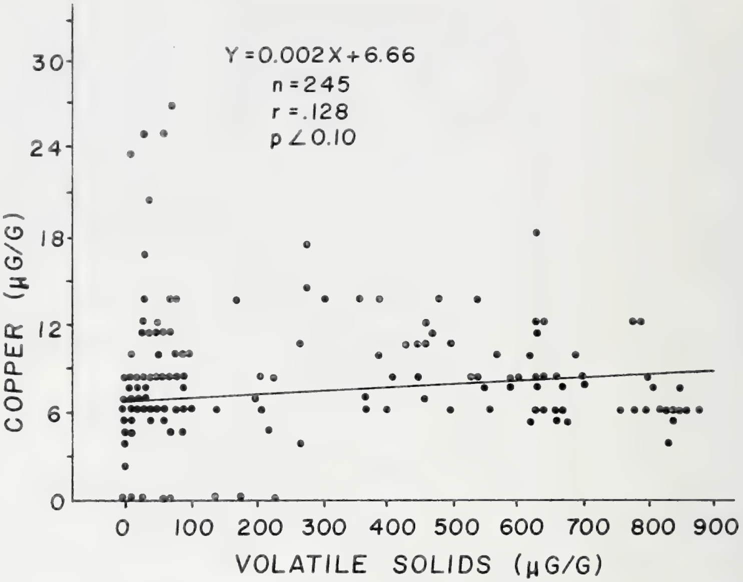

Fig. 6. Relationship of copper to sediment volatile solids.

Liver Iron Concentration (ug/g) = 480.8 (Coefficient of Condition) − 327.3 (1)

$$\text{where} \quad \text{Coefficient of Condition} = \frac{\text{Fish Weight (grams)} \times 10^5}{\text{Fish Total Length (mm)}^3} \tag{2}$$

A series of negative correlation coefficients were obtained when copper and zinc concentrations in the tissues of bluegill and largemouth bass were compared to body length and weight. The negative correlations suggest that, as these fish age, more efficient means are available for excreting copper and zinc from the body, or that avoidance behavior to higher concentrations is learned.

Water quality-land use relationships were statistically evaluated by multiple regression techniques in order to identify nonpoint sources of variability in surface water levels of trace metals. Stepwise multiple regression techniques described by Haith (1976) for the study of land use and nonpoint source impacts on water quality were used in this investigation. Land use percentages for the 4 watersheds of the upper St. Johns River sampled within in this study are in Table 3. Following an arcsine transformation of the land use percentages to prevent the variance of a binomial distribution for being a function of the mean, correlations between watershed land use and trace metal levels were calculated. These results, listed in Table 4, demonstrated that although total copper and total zinc were highly cor-

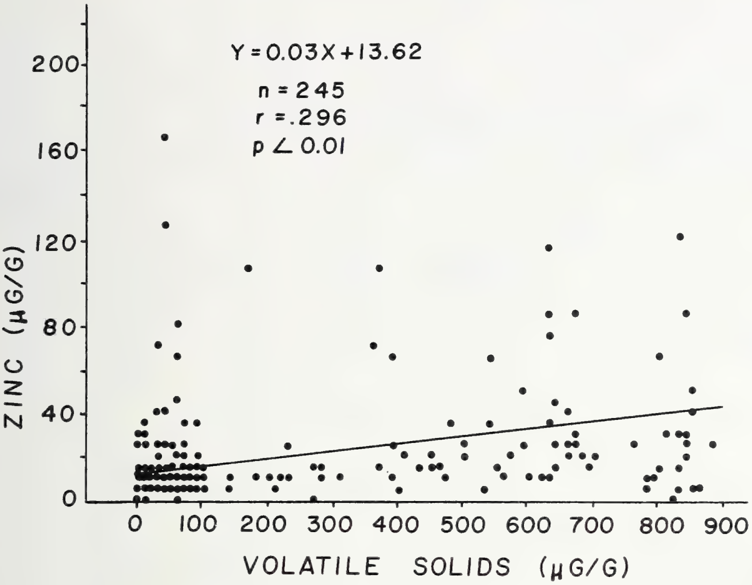

Fig. 7. Relationship of zinc to sediment volatile solids.

related to several land uses, total iron exhibited no significant correlations. Total copper was most highly correlated with residential land use, while total zinc was most strongly correlated with commercial-institutional-industrial uses.

The multiple regression equations generated to predict the relationships between land uses and surface water levels of total copper and total zinc within watersheds SJ-1, SJ-2, SJ-3, and SJ-5 are in Table 5. The final equation for total copper (step 2) explained 99.68% ($r^2 = 0.9968$) of the observed variation, with residential areas (Res) accounting for approximately 92% of this variation and marsh accounting for the remainder. Transportation (Trans) and commercial-institutional-industrial areas (C-I-I) explained 98.62% of the observed variation in total zinc levels with C-I-I accounting for nearly 96% of the variation. Because of collinearities present in the land uses of the 4 watersheds (e.g., urban uses tend to increase while agricultural uses proportionately decrease), an equation using percent C-I-I land use accounted for 95.60% of the observed variation in average total zinc, while and equation employing percent residential land use was nearly as suitable, explaining 95.26% of the variation. Although present concentrations of total copper and total zinc in the surface waters of the upper St. Johns River are low, the regression results indicate that as the extent of human utilization and urbanization of agricultural and undeveloped watersheds increases and natural land cover decreases, total copper and zinc concentrations in the surface waters can also be expected to increase.

TABLE 2. Average trace metal concentrations in fish tissue.

Species	Number Analyzed	Metal	Tissue	Concentration (ug/g, wet weight)	
				Mean	Range
Largemouth Bass	28	Iron	Muscle	11.8	ND- 58.4
(Micropterus salmoides)			Gill	55.3	17.4-270.3
			Liver	207.8	47.5-381.0
	28	Copper	Muscle	2.9	ND- 13.6
			Gill	7.3	ND- 39.7
			Liver	11.2	2.7- 44.1
	28	Zinc	Muscle	9.2	ND-131.3
			Gill	24.3	7.9- 50.6
			Liver	37.6	ND-116.2
Speckled Perch	3	Iron	Muscle	3.2	1.8- 5.1
(Pomoxis nigromaculatus)			Gill	24.8	ND- 43.9
			Liver	86.2	23.6-165.8
	3	Copper	Muscle	3.6	1.3- 4.7
			Gill	11.5	2.3- 16.3
			Liver	10.7	10.0- 11.0
	3	Zinc	Muscle	8.6	0.6- 16.4
			Gill	23.3	15.7- 30.2
			Liver	37.0	21.6- 67.3
Bluegill	12	Iron	Muscle	8.0	ND- 25.2
(Lepomis machrochirus)			Gill	55.3	13.0-223.7
			Liver	126.0	20.1-232.5
	12	Copper	Muscle	3.6	ND- 10.3
			Gill	10.3	1.1- 49.4
			Liver	29.1	3.9-182.1
	12	Zinc	Muscle	15.2	ND-104.3
			Gill	43.3	15.7-128.0
			Liver	42.8	11.7- 87.8
Eastern Chubsucker	3	Iron	Muscle	2.2	ND- 3.7
(Erimyzon succetta)			Gill	35.9	ND- 80.2
			Liver	114.4	91.6-130.3
	3	Copper	Muscle	1.9	1.3- 2.5
			Gill	4.1	2.3- 5.0
			Liver	11.7	9.3- 14.8
	3	Zinc	Muscle	7.8	5.4- 12.3
			Gill	27.3	26.2- 29.4
			Liver	30.3	22.5- 37.2

ND = not detectable.

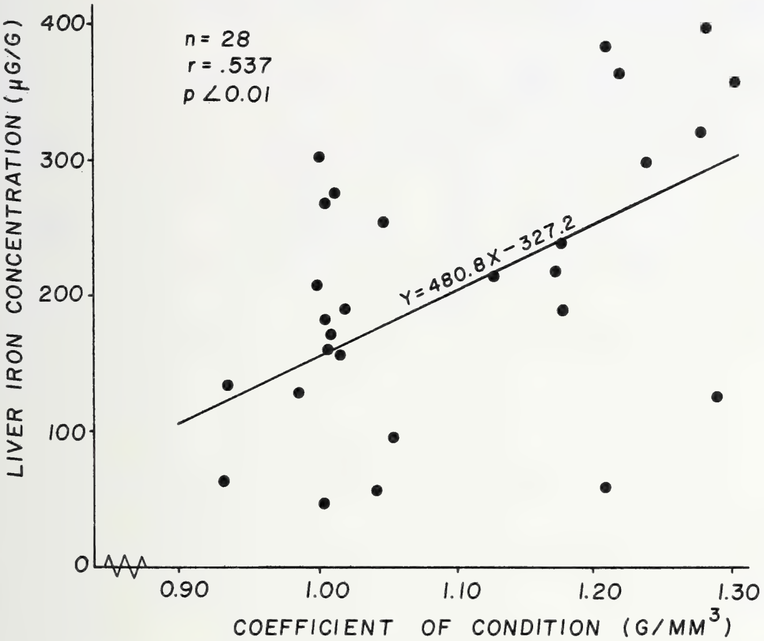

Fig. 8. Iron concentrations in the liver of largemouth bass as a function of coefficients of condition.

Summary and Conclusion—Findings from our research indicate that:

1. Although total copper and total zinc were present in low concentrations in the surface waters of the upper St. Johns River, total iron frequently occurs in concentrations exceeding the state standard of 300 ug/l set by the Florida Department of Environmental Regulation for Class I waters.

2. Levels of total iron in the surface waters of the upper St. Johns River appear to be regulated by resuspension of bottom sediments caused by increased discharge and resulting turbulence.

3. Groundwater inputs from springs, wells, or upward seepage through the lake and canal sediments may also influence the trace metal content of the surface waters. Because total iron concentrations in nonartesian groundwater are high, significant contributions of iron is likely added to the surface waters from nonartesian or bank seepage.

4. Average surface water total iron concentrations were highest in the headwaters region of the river above Lake Helen Blazes, decreased in a northward direction to Lake Washington, and increased to Lake Poinsett. Highest average concentrations of total copper and total zinc were measured in the surface waters of Lake Poinsett and Lake Washington, where groundwater seepage and land runoff into the drainage canals add elevated levels of trace metals into the mainstem of the river. Groundwater inputs, particularly from nonartesian wells, are thought to be responsible for increasing

TABLE 3. Watershed land uses of upper St. Johns River Basin (from Brevard County Zoning and Planning Commission).

Percent Land Use Within Watershed				
SJ-1	SJ-2	SJ-3	SJ-5	Land Use Category
0.07	0.02	1.40	7.03	Residential
		0.33	2.40	Comm-Instit-Industrial
60.05	35.32	38.44	13.50	Agriculture
37.74	64.44	45.57	46.54	Marsh
0.11		13.66	28.90	Vacant
0.03	0.22	0.60	1.63	Transportation

TABLE 4. Significant correlations between land use and water quality parameters.

Land Use	Total Iron	Total Copper	Total Zinc
Residential	—	0.958*	0.976*
Agricultural	—	—	—
Marsh	—	—	—
Vacant	—	0.939*	0.913*
Transportation	—	—	0.889*
Commercial-Institutional-Industrial	—	0.945*	0.978**

*Significant at 0.05 confidence level.
**Significant at 0.01 confidence level.

TABLE 5. Multiple regression equations for explaining water quality-land use relationships.

Step	Equation	Explained Variance r^2	F-value	Significance Level
TOTAL COPPER:				
1	Copper = 0.56 + 0.36 (Arcsine % Res)	0.9185	22.55	0.05
2	Copper = 6.04 + 0.32 (Arcsine % Res) − 0.12 (Arcsine % Marsh)	0.9968	154.39	0.10
TOTAL ZINC:				
1	Zinc = 11.20 + 0.84 (Arcsine % C-I-I)	0.9560	43.41	0.025
2	Zinc = 12.84 + 1.34 (Arcsine % C-I-I) − 0.83 (Arcsine % Trans)	0.9862	35.72	—
% C-I-I deleted from equation:				
	Zinc = 10.55 + 0.52 (Arcsine % Res)	0.9526	40.20	0.025

surface water concentrations of total iron in the headwater region of the upper St. Johns River.

5. Higher levels of iron (r = .617; $p < 0.01$), copper (r = .128; $p < 0.10$), and zinc (r = .296; $p < 0.01$), were found in sediments containing higher percentages of organic matter (volatile solids), suggesting that humic substances deposited in these sediments during decomposition of vegetation complex with metal ions forming a sink for the metals.

6. Analysis of iron, copper, and zinc in the tissues of largemouth bass, speckled perch, eastern chubsucker, and bluegill indicated that these metals are concentrated in the fish liver, while lower concentrations are found in the gill and lowest levels are found in muscle tissue. Exceptions to this trend were the gills of speckled perch and bluegill where higher average copper and zinc concentrations occurred, respectively. Statistical results suggested that iron accumulates in the liver of largemouth bass through time and that more efficient means of excreting copper and zinc are available to largemouth bass and bluegill as the fish ages.

7. Multiple regression techniques used to evaluate water quality-land use relationships demonstrated that levels of total copper and total zinc were highly correlated to land uses associated with urban activities. Average total copper concentrations were best predicted by an equation using percent residential land use, while total zinc levels were best predicted using percent commercial-institutional-industrial use or one using percent residential use. These results indicate that as the extent of human utilization of undeveloped watersheds increases and natural land cover decreases, total copper and total zinc concentrations can also be expected to increase in the surface waters of the upper St. Johns River.

ACKNOWLEDGMENTS—This research was conducted as a masters degree thesis and as part of a water quality and supply evaluation of Lake Washington by the Environmental Science and Engineering Department of Florida Institute of Technology, Melbourne, Florida. The project was supported by Florida Institute of Technology, the City of Melbourne, and the Florida Department of Environmental Regulation and has been presented to the American Fisheries Society Warmwater Streams Symposium, Knoxville, Tennessee, March, 1980.

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POPULATION CHARACTERISTICS OF *PROCYON LOTOR MARINUS* IN ESTUARINE MANGROVE SWAMPS OF SOUTHERN FLORIDA

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Abstract: *Population characteristics of* Procyon lotor marinus *were studied in estuarine mangrove swamps of southwestern Florida. Of 497 raccoons captured, 297 were tagged and released, and 200 were used for necropsy or other studies. The population was characterized by lack of a sharply-defined breeding season and relatively low rates of reproduction and turnover. Breeding extended from March through August with births occurring from May through October. Mean litter size was 2.87. Densities were estimated to range from 2.2-6.5/km^2 and generally were highest in fall and winter. Adults made up 69% of the raccoons captured, subadults 20%, and immatures ($\leq$ 30 wk) 11%. Sex ratios favored males in all age classes.*

Within the last decade, much of the estuarine mangrove swamp along Florida's Gulf Coast has been dredged and filled by land developers. Such habitat destruction accompanied by increased human habitation, when it occurs rapidly, alters the normal activity patterns of native raccoons and concentrates them in remnant woodlots and swamps, resulting in dense populations of semidomesticated raccoons that scavenge and beg from human benefactors. The introduction of rabies virus or other disease into such raccoon populations can have profound public health implications (Bigler et al., 1973).

Florida's rather discrete population of Ten Thousand Island raccoons *(Procyon lotor marinus)*, much of which occurs on islands undergoing development, may be particularly vulnerable to environmental manipulations and disease outbreaks. However, the impact of these and other factors on population dynamics cannot be adequately assessed because information regarding this subspecies is fragmentary. *P. l. marinus* was described nearly a half century ago (Nelson, 1930); but until recently, the only notes confirming its existence and distribution were those of Goldman (1950) and Hall and Kelson (1959). Since 1970 a multifaceted project conducted by the Florida Department of Health and Rehabilitative Services has produced a series of papers providing data on the *P. l. marinus* population of Marco Island, including some morphologic and physiologic characteristics, diseases, and levels of chemical pollutants in the population (Bigler et al., 1973, 1974, 1975, 1977; Doyle et al., 1975; Hoff et al., 1974; Nalley et al., 1975; White et al., 1975). We describe some population characteristics of *P. l. marinus* on several keys in the vicinity of Marco Island between 1970 and 1974.

STUDY AREA—Marco Island, located south of Naples, occupies the northern portion of the saline mangrove zone known as the Ten Thousand Island chain in southwestern Florida (Craighead, 1971). The core study area was a 7.15-km^2 portion of Big Key, a mangrove island between Marco Island and Goodland. The climate is subtropical with a mean (1971-1973) annual temperature of 23.7°C and monthly means ranging from 16.4°-28.2°C (U.S. Dept. of Commerce, Naples Station, 1971, 1972, 1973). The mean annual precipitation for the 3-yr study period was 124 cm. Over 75% of the annual rainfall was recorded from June through September. The dominant species of the scrub association is the red mangrove *(Rhizophora mangle)*, which with its prop roots forms an almost impenetrable jungle. Soils range from deep sand and mounds of marine shell on the main island to mangrove peat under the mangrove islands. The area is watered by saline tides, but the interior of the main island has pools of fresh to brackish water throughout the year. The islands of mangrove swamp also have accumulations of fresh water in tree stumps and hollows during the rainy season.

METHODS—Raccoons were live-trapped during thirteen 4-night trapping periods, generally at 3-4 mo intervals, from December 1970 through July 1974. The mangrove swamp-waterway interface was sampled via 65 trapping stations approximately 320 m apart. At each station a wire-mesh box trap was tied to mangrove prop roots or branches or placed on a shell bar. An outboard-powered runabout was used to check and maintain the traps. All raccoons captured from Big Key were marked and released. Most of those taken from the Marco Island mainland were killed to obtain organs and tissues for study.

Captured raccoons were either processed in the boat near the trapping stations or at a central area on the mainland. Animals scheduled for release were induced into light anesthesia with ketamine hydrochloride (Bigler and Hoff, 1974), ear-marked with standard numbered monel metal or aluminum tags, weighed, measured, and examined for age, sex and breeding condition. Euthanized animals, in addition to being weighed, measured and examined externally, were dissected to obtain skulls, female reproductive tracts and other tissues as required for concurrent studies reported elsewhere.

All raccoons were separated into juvenile and adult age classes by the methods described by Sanderson (1961a) and by tooth wear. Adults that were necropsied were aged by the closure of sutures of the skull. Lower incisors of selected adults also were sectioned and examined for cementum layers. Techniques for estimating age by tooth wear, suture-closure and cementum layers were those described by Grau et al. (1970). Immatures selected for necropsy were aged by suture-closure and eye lens weight (Sanderson, 1961b; Johnson, 1970). Daily measurement data from 2 raccoons trapped at 3.5 mo of age and raised in captivity for 20 wk were used to prepare an approximate growth curve. All juvenile raccoons captured and released were then classified into 2 age groups. Raccoons with total length $<$ 350 mm were judged to be $\leq$ 15 wk of age, and those with total length between 350 and 400 mm were judged to be 16-30 wk old. Animals over 400 mm long but judged not to be breeding adults were classed as subadults.

All female raccoons necropsied were examined for condition of the uterus, number of implantation sites and number and size of embryos. Conception dates and birth dates were estimated from the fetal growth curves of Llewellyn (1953) and Sanderson and Nalvandov (1973). Ovaries were examined for corpora lutea and follicle development. Breeding condition of released females was assessed by the condition and color of the teats, lactation and swelling of the vulva.

Densities per km² were estimated by the calendar of captures method (Petrusewicz and Andrzejewski, 1962). Movements were expressed as the frequency of distances between successive captures (Faust et al., 1971).

Results and Discussion—A total of 497 raccoons was trapped on Big Key (277) and the Marco Island mainland (220). All of those from Big Key were tagged and released, and 200 of those from Marco Island were removed for necropsy and experimental study. There was no other significant hunting or trapping of raccoons.

The estimated density of raccoons for the study area on Big Key ranged from 2.2 (May 1972) to 6.5 (December 1973) animals/km² (mean 3.9/km²) during the study period (Table 1). These are conservative estimates as only captured animals are counted in the calendar of captures method. Also, estimates calculated from results for 4 trapping periods probably were low

Table 1. Population estimates of *Procyon lotor marinus* on the Big Key study area, 1970-1974.

Trapping Period	Number Captured	Trap Nights/ Raccoon	Density/ km²
1970			
December	26	2.9	3.6
1971			
March	24	4.0	3.6
June	20	6.3	4.2
October[a]	11	5.2	3.1
1972			
January[a]	8	7.6	2.5
May[a]	11	7.5	2.2
December	37	5.2	5.1
1973			
April	17	3.2	4.0
June	26	6.8	4.4
September	29	6.8	5.7
December	41	4.3	6.5
1974			
March	23	7.2	3.6
July[a]	4	6.0	2.3
Composite mean	21	5.6	3.9

[a] Logistical problems precluded trapping coverage of the entire area.

because logistical problems affected trapping coverage of the study area. Following the epizootic of raccoon rabies in the fall of 1970 (Bigler et al., 1973), population density increased gradually for the next 3 yr, and by December 1973 was nearly doubled. Highest densities were recorded in the fall and winter, except in the winter of 1971-72 when estimates probably were low as indicated above. Population density on the Marco Island mainland could not be estimated by the calendar method because raccoons were removed for other studies.

Fifty-two (18%) of the 297 tagged raccoons were recaptured a total of 72 times. Forty-two of these were recaptured only once (5 were subsequently removed for disease and parasite studies); the other 10 were recaptured up to 6 times each. Intervals between recaptures ranged from 3-40 mo; 81% of the recaptures occurred within 12 mo.

Distances between successive captures, obtained by straight line measurement between capture points, were all less than 4,400 m (Table 2). Thirty of the raccoons (42%) were recaptured at least once at the original capture site and only 8 (11%) were taken more than 1200 m from the original sites of capture. Nine raccoons traveled to or from mangrove islands separated from Big Key by 165-645 m of open water. The average distance between captures was greater for females (673 m) than for males (486 m).

The seasonal age composition of the trapped segment of the population ranged from 62-81% (mean 69%) adults and from 13-29% (mean 20%) subadults. Immature raccoons ≤ 30 wk of age composed 11-15% of the collections from November through March. This group diminished to < 10% from April through October. Immature raccoons ≤ 15 wk old were captured only from September through December. The low percentage of im-

TABLE 2. Frequency of distances between successive captures for *Procyon lotor marinus*, Marco Island, 1970-1974.

Distance (Meters)	Number of Recaptures	Percentage Frequency	Accumulative Percentage
Recaptured at same site	30	41.7	41.7
50-200	7	9.7	51.4
201-400	13	18.0	69.4
401-600	4	5.6	75.0
601-800	3	4.1	79.1
801-1000	4	5.6	84.7
1001-1200	3	4.1	88.8
1801-2000	1	1.4	90.2
2001-2200	1	1.4	91.6
2601-2800	2	2.8	94.4
3201-3400	2	2.8	97.2
3601-3800	1	1.4	98.6
4201-4400	1	1.4	100.0
Total	72	100.0	100.0

mature raccoons in the population is consistent with findings of other studies in southern portions of the range (Johnson, 1970).

Analysis of cranial sutures and cementum layers also provided information on longevity. Ten of 19 (53%) adults aged by suture closure were determined to be ≥ 3½ yr of age. When animals in this series were aged by wear class, 11 of 19 (58%) were judged to be ≥ 3½ yr of age. Only 5 of the 19 (26%) were judged to be > 3 yr of age via examination of cementum layers in lower central incisors.

Sex ratios of captured raccoons favored males in all age classes (immature < 15 wk, 4.00:1; immatures 16-30 wk, 1.81:1; subadults, 1.32:1; adults, 1.49:1). The composite ratio for all 497 raccoons examined was 1.50:1 (60% males). The degree of bias associated with the capture method could not be determined.

Reproductive tracts from 62 adult females were examined postmortem (Table 3). Of 34 females collected during the months of April through September, 9 were pregnant and 12 were in estrus. Calculated breeding dates for the 21 pregnant or estrous raccoons were distributed by month as follows: March (1), April (6), May (1), June (8), July (3), August (2). The earliest conception date calculated was March 6; the latest was August 17. The earliest estimated birth date was May 8; the latest was October 19. Potential births of 9 sets of fetuses were distributed as follows: May (1), June (2), July (1), August (2), September (1), October (2). Of 28 adult females collected during the months of November through March, none were reproductively active.

These data indicate a breeding season extending from March through August with most births occurring from May through October. They suggest there may be 2 poorly defined peaks in breeding (April and June). These conclusions are supported by data from external examination of 142 adult

TABLE 3. Reproductive condition of 62 adult female raccoons by month of collection, Marco Island, 1970-1974.

Month	Number Examined	In Estrus	Pregnant	Postpartum	Inactive
January	1				1
February	0				
March	8				8
April	6	4	1		1
May	2		2		
June	9	6	2		1
July	3	2	1		
August	5		1	2	2
September	9		2	1	6
October	0				
November	8			7	1
December	11			10	1

females captured, tagged and released. Adult females with swollen vulvas were captured in April (33% of captures for the month) and June (24%); and pregnancies were recorded in May, June and September. Lactating animals were captured in September (41% of adult females captured), November (30%), December (31%) and January (25%). Estimated birth dates of 64 immature raccoons also indicated that most births occur from May through October. Raccoons in Coastal Plain areas of Georgia and Alabama produce most young in May and June (McKeever, 1958; Johnson, 1970).

Mean litter size was calculated from 9 sets of fetuses (2.89, SE = 0.26), 26 sets of implantation sites (2.89, SE = 0.21) and corpora lutea counts in 4 reproductive tracts with preimplanted pregnancies (2.75, SE = 0.35). The mean for combined data from fetuses, implantation sites and corpora lutea (39 reproductive tracts) was 2.87 (SE = 0.14).

Previous studies indicate that in southern portions of their range raccoons tend to have lower rates of reproduction and turnover than in northern areas. Also, the breeding season is longer and the peak of breeding occurs later in the year (see Johnson, 1970 for a review and discussion). Our data from Marco Island provide further evidence of these differences.

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A METHOD FOR REARING SIMOCEPHALUS IN THE LABORATORY—*Charles P. White*, Department of Zoology, University of Florida, 223 Bartram Hall, Gainesville, Florida 32611.

Abstract: *I describe a method that I find successful for rearing 3 species of* Simocephalus *(Cladocera) in the laboratory under controlled conditions and present results of tests that demonstrate the effectiveness of the method.*

To study life history features of cladocerans, a consistent rearing technique that can be duplicated over long periods of time and that allows uniform growth, survival, and reproduction for many generations is needed. I describe 5 major components of a method that has been used successfully for rearing 3 species of *Simocephalus* and present results of tests that demonstrate the effectiveness of the method.

Food—Unialgal cultures of the unicellular green alga *Stichococcus bacillaris* Näg. obtained from a contaminated flask of culture medium provided a consistent and easily quantifiable source of food that met the nutritional requirements of the cladocerans. Algal cultures were grown under cool white fluorescent lights in 2 ℓ flasks containing Bold's Basal "3N" growth medium (Bold, 1967, See Appendix). The flasks were plugged with cotton through which glass tubes extending into the liquid were inserted. Filtered air was pumped through these tubes to aerate and agitate the cultures.

Simocephalus were provided with algal cells at a concentration of 500,000 cells/ml, which apparently provided a superabundant food supply. Hutchinson (1967) reported that *Simocephalus vetulus* reaches a plateau of feeding efficiency at food concentrations between 250,000 and 500,000 cells/ml. Food was prepared each day by counting the individual cells in a known volume of algal stock with a hemacytometer and diluting this stock to the proper concentration.

Water—Water was conditioned by passage through two 110 ℓ aquaria. Tap water was introduced into the first tank, which contained numerous small fish, a large population of snails, and a dense growth of *Vallisneria*. A fluorescent light in the hood was kept on continuously, and the 568 ℓ/hr motor driven filter was cleaned every week. Water was siphoned from this tank to another unilluminated one which contained a few fish and snails but no plants. This aquarium had both an undergravel filter and a 568 ℓ/hr motor driven filter. Water from the second aquarium was placed in 2 ℓ flasks and autoclaved for 15 min at 121°C under 1,520 mm Hg. Taub and Dollar (1968) reported that autoclaved culture water boosted survival and reproduction in *Daphnia pulex*. After cooling overnight, the water was mixed with the algal stock and used.

TEMPERATURE—Experimental cultures were reared at 27°C. Other cultures raised at 20°C and 30°C indicate that this setting is within the tolerance range of *Simocephalus*.

LIGHT—An illumination schedule of 12 hr light and 12 hr dark was maintained. Animals reared under 24 hr of light did well, while those raised in complete darkness usually died, indicating that some light is important.

REARING TESTS—Each *Simocephalus*, a "granddaughter" of a wild, parthenogenetically reproducing adult, was kept in its own container, a 220 ml capacity plastic cup containing 60 ml of the diluted algal culture. These cups were kept on white trays in an environmental chamber. Each day the contents of the cup were poured into an illuminated 76 mm glass culture dish, the cladoceran was transferred with an expanded eye dropper to a duplicate cup containing fresh food, and the newborn were collected by pouring them into a 74 micron sieve. Offspring from clones of 10 siblings were collected on the sieve, washed into a plastic pill vial, killed with 10% formalin, and counted at 12 power with a dissecting microscope. Body lengths were measured at 24 power using a dissecting microscope with a measuring eyepiece. Algal build-up was removed from the sides and bottom of the culture cups each week.

EVALUATION OF METHOD—Three questions must be considered before confidence can be placed in the technique. Does it allow high rates of survival and reproduction? The survival rates to age 14 da of clones of *S. exspinosus*, *S. serrulatus*, and *S. vetulus* are in Table 1, and the mean intrinsic rates of natural increase, r_m, for the same clones are in Table 2. These tables indicate that the method allows high rates of survival and reproduction. Does it allow consistency over a long period of time? In Table 3, body lengths at age 14 da and r_m values of individuals from January and April cohorts of the same clones indicate that consistency is maintained. Does it allow consistency between parents and offspring? For 10 parent-offspring pairs, a paired comparison "t" test showed no difference between the total number of young produced by age 14 da ($0.4 > p > 0.2$) or between the body length at age 14 da ($0.9 > p > 0.5$).

SUMMARY—I describe a method that has been used successfully for rearing 3 species of *Simocephalus* and present results of tests that demonstrate the effectiveness of the method. *Simocephalus* were raised in individual plastic cups containing 60 ml of a unialgal culture of *Stichococcus bacillaris* diluted to a concentration of 500,000 cells/ml with autoclaved aquarium water. The cladocerans were kept in an environmental chamber at 27°C with 12 hr of light and 12 hr of darkness and were provided with fresh algal culture each day. This method allowed high and constant rates of growth and reproduction in 3 species of *Simocephalus* over long periods of time.

TABLE 1. Survival rate of 3 species of *Simocephalus* cladocerans to age 14 days.

	S. exspinosus	*S. vetulus*	*S. serrulatus*
$\bar{X}$	0.91	0.82	0.90
S^2	0.029	0.044	0.012
Number of clones	40	9	5

TABLE 2. Intrinsic rate of increase (r_m) for 3 species of *Simocephalus*.

	S. exspinosus	*S. vetulus*	*S. serrulatus*
$\bar{X}$	0.619	0.612	0.417
S^2	0.005	0.003	0.001
Number of clones	40	9	5

TABLE 3. Body length of age 14 days and r_m values for January and April cohorts of the same clones of *Simocephalus*.

Species	Date	r_m	Body Length mm
S. exspinosus	25 January	0.706	2.61
	13 April	0.702	2.59
S. vetulus	20 January	0.579	1.89
	14 April	0.580	1.91

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Florida Sci. 44(3):157-160. 1981.

APPENDIX

Bold's Basal Medium "3N"

Six stock solutions are made by adding the following salts to 400 ml water:

$NaNO_3$	30 g
$CaCl_2 \cdot 2H_2O$	1 g
K_2HPO_4	3 g
KH_2PO_4	7 g
$MgSO_4 \cdot 7H_2O$	3 g
NaCl	1 g

Four trace element stocks are prepared as follows:

EDTA Stock: To 1 liter water add

EDTA	50 g
KOH	31 g

Iron Stock: To 1 liter acidified water add 4.98 g $FeSO_4 \cdot 7H_2O$. Acidify water by adding 1 ml concentrated H_2SO_4 to 999 ml water.

Boron Stock: To 1 liter water add 11.42 g H_3BO_3.

Miscellaneous Stock: To 1 liter acidified water add

$ZnSO_4$	8.82 g
$MnCl_2$	1.44 g
MoO_3	0.71 g
$CuSO_4 \cdot 5H_2O$	1.57 g
$Co(NO_3)_2 \cdot 6H_2O$	0.49 g

To 940 ml water add 10 ml of each of the 6 stock solutions and 1 ml of each of the 4 trace element solutions. Keep stocks refrigerated.

PLANKTONIC FORAMINIFERA COLLECTED BY THE R/V MELVILLE (1972) IN THE SOUTHWEST ATLANTIC

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ABSTRACT: *The planktonic foraminiferal fauna was studied from 186 samples collected by the R/V Melville in the Southwest Atlantic Ocean during 1972. The samples were collected in the surface layer (horizontal tows) and throughout the water column from 500-0 m. (vertical tows). Twenty species were recognized (some with various* formae). *These species can be divided according to their temperature requirements into cold-temperate, warm-temperate, warm and cosmopolitan species. Based on the distribution of these species, 4 types of surface water were determined.*

THE objectives of this work were: a) to study qualitatively and quantitatively the distribution of the planktonic foraminiferal fauna collected by the R/V Melville (October-November 1972) in the Southwest Atlantic Ocean, and b) to attempt to separate different water masses on the basis of the distribution of planktonic foraminifera.

MATERIAL—The material studied consisted of 186 planktonic samples (Fig. 1): 21 were collected through the water column from 500-0 m (vertical samples) and 165 were horizontal samples taken from the surface water layer using of the pump-filter method.

Planktonic foraminifera were found in only 9 of the vertical and in 30 of the horizontal samples. This was probably because most of the samples were collected over the continental shelf which does not favor the occurrence of planktonic foraminifera (Boltovskoy, 1970).

SURFACE HYDROLOGY OF THE SOUTHWEST ATLANTIC—The hydrology of the southwest Atlantic was described in detail by Boltovskoy in 1970 and 1978.

In the South Atlantic, the warm subtropical waters of the Brazilian Current converge with the cold subantarctic waters of the West Wind Drift and its western branch, the Falkland Current. The contact between these water masses is known as the Subtropical/Subantarctic Convergence (Fig. 1). This is a wide zone of belts, tongues and patches, of different mixtures of subtropical and subantarctic waters. The northern limit of the zone of convergence is located in summer at 29°S latitude and in winter at 34°S. The southern limit has less seasonal changes in summer; it is at 47-48°S and in winter at 47°S (Boltovskoy, 1970).

SYSTEMATICS—Most of the species determined in the surface samples were represented by a few, small specimens, while in the vertical samples numerous, large specimens were found.

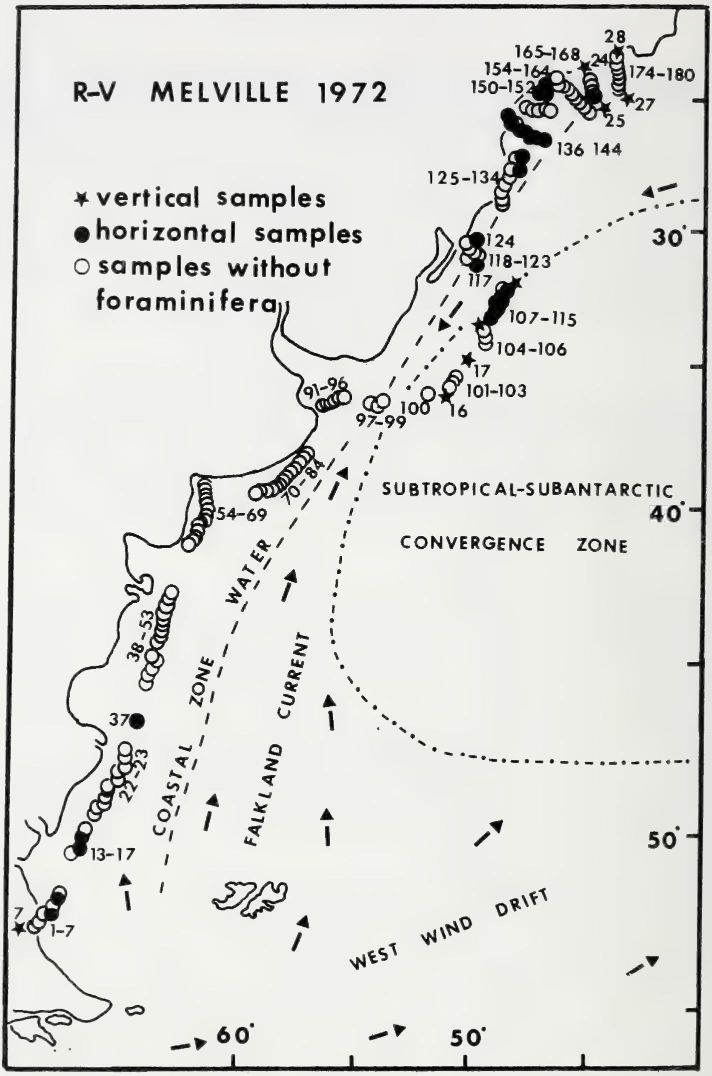

Fig. 1. R/V Melville (1972) sample locations. Hydrologic scheme after Boltovskoy, 1970.

Most of the species were easy to identify except for a few juveniles that showed intermediate characteristics between *Globoquadrina pachyderma* and *G. dutertrei*. We consider these as *G. pachyderma/G. dutertrei*. The strong morphological similarities and the gradual and nearly continuous gradation between these 2 species were noted by Kennett (1976). *Globorotalia menardii, forma typica* and *G. menardii, forma tumida* were also difficult to separate because they are connected by a series of transition specimens. We consider these as *G. menardii (sensu lato)*.

The following species were represented in more than 1 form.

Globigerinoides ruber has 3 forms; 2 on the basis of the wall color *(forma alba* and *forma rosea)* and 1 on the basis of test morphology *(forma elongata)*. The first 2 forms tolerate different ecological changes. In the warm open sea, *forma rosea* (pink wall colored) is more abundant. In unfavorable changes (e.g., low salinity, low temperature, proximity of the coast), *forma alba* (white wall colored) is more frequent (Boltovskoy, 1968). *Globigerinoides trilobus* was represented by 2 forms: *forma typica* and *forma sacculifera*. *Forma sacculifera* is less tolerant to low temperature than the other one. *Globoquadrina dutertrei* was represented by 2 forms: *forma typica* and *forma eggeri*.

The most abundant species and also the one that showed the widest distribution was *Globigerinoides ruber (sensu lato)*, followed by *Globorotalia menardii (sensu lato)*, *G. inflata*, *Globigerinoides trilobus (sensu lato)*, *Globigerinella aequilateralis*, *Hasterigerina pelagica*, *Globigerinita glutinata*, *Globorotalia hirsuta*, *G. scitula* and *G. truncatulinoides*. The other species were represented by a few scattered specimens (Tables 1 and 2).

All species determined, arranged in alphabetical order, are as follows:

Candeina nitida Orbigny, 1839, *In:* de la Sagra Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 108, pl. 2, figs. 27-28.

Globigerina bulloides Orbigny, *forma trilocularis* Orbigny = *Globigerina trilocularis* Orbigny, 1826, Ann. Sci. Nat., v. 7, p. 277, no. 2.

Globigerina calida Parker, 1962, Micropaleontology, v. 8, p. 221, pl. 1, figs. 9-13, 15.

Globigerina hexagona Natland, 1938, Scripps Inst. Ocean., Techn. Ser., v. 4, no. 5, p. 149, pl. 7, fig. 1.

Globigerina rubescens Hofker, 1956, Copenhagen Univ., Zool. Mus., Spolia, v. 15, p. 234, pl. 35, figs. 18-21.

Globigerinella aequilateralis (Brady), *forma involuta* Cushman, 1917, U.S. Nat. Mus., Proc., v. 15, no. 2172, p. 662.

Globigerinita glutinata (Egger) = Globigerina glutinata Egger, 1893, Abh. K. Bayer, Akad. Wiss. München, Cl. II, v. 18, p. 371, pl. 13, figs. 19-21.

Globigerinoides conglobatus (Brady) = *Globigerina conglobata* Brady, 1879, Quart. J. Micr. Sci. n.s., v. 19, p. 286; 1884, Rept. Voy. "Challenger", Zool., v. 9, pl. 80, figs. 1-5; pl. 82, fig. 5.

Globigerinoides ruber (Orbigny) = *Globigerina ruber* Orbigny, 1839, *In:* de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 82, pl. 4, fig. 12-14.

- *Globigerinoides ruber* (Orbigny), *forma typica* (Orbigny), *ut supra.*
- *Globigerinoides ruber* (Orbigny), *forma alba* Boltovskoy, 1968, Rev. Micropaleontologie, v. 11, no. 2, p. 89.
- *Globigerinoides ruber* (Orbigny), *forma elongata* (Orbigny) = *Globigerina elongata* Orbigny, 1826, Tabl. Méth. Ann. Sci. Nat. Paris, Sér. 1, v. 7, p. 277.
- *Globigerinoides ruber* (Orbigny), *forma rosea* Boltovskoy, 1968, Rev. Micropaleontologie, v. 11, no. 2, p. 89.

Globigerinoides trilobus (Reuss) = Globigerina triloba Reuss, 1850, K. Akad, Wiss. Wien. Denkschr., v. 1, p. 374, pl. 47, fig. 11.

- *Globigerinoides trilobus* (Reuss), *forma typica* (Reuss), *ut supra.*
- *Globigerinoides trilobus* (Reuss), *forma sacculifera* (Brady) =
- *Globigerina sacculifera* Brady, 1877, Geol. Mag., n.s., v. 4, no. 12, p. 535; 1884, Rept. Voy. "Challenger", Zool, v. 9, p. 604, pl. 80, figs. 11-17; pl. 82, fig. 4.

Globoquadrina dutertrei (Orbigny) = *Globigerina dutertrei* Orbigny, 1839, *In:* de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 84, pl. 4, fig. 19-21.

- *Globoquadrina dutertrei* (Orbigny), *forma typica* (Orbigny), *ut supra.*
- *Globoquadrina dutertrei* (Orbigny), *forma eggeri* Rhumbler, 1901, *In:* Brandt, Nordisch Plankton, Lief. 1, no. 14, p. 19, fig. 20.

Table 1. Planktonic Foraminifera found in surface horizontal samples (R/V Melville, 1972). Specimens number: R (rare) < 5, C (common) = 6-24, A (abundant) = 25-49, P (predominant) > 50.

Horizontal Sample Number	4	6	14	37	107	109	110	111	112	114	115	117	124	127	131	132	134	135	136	138	139	140	141	142	143	144	151	152	153	165
GLOBOQUADRINA PACHYDERMA (f. superficiaria)		R		R																										
GLOBIGERINA BULLOIDES (f. trilocularis)			R	R																										
GLOBOROTALIA INFLATA	R		R					R		R																				
GLOBIGERINOIDES RUBER (f. alba)					R	R			R		R			R	R	R	R	R	R	C	R									
GLOBIGERINOIDES RUBER (f. rosea)					R		R		R	R	R	R	R					R	R	R	R	R	R	R						
GLOBIGERINOIDES TRILOBUS (f. typica)						R	R	R			R							R												
GLOBIGERINELLA AEQUILATERALIS (f. involuta)									R								R													
GLOBOQUADRINA PACHYDERMA/G. DUTERTREI																			R											
ORBULINA UNIVERSA																			R											
HASTERIGERINA PELAGICA																			R											
GLOBOROTALIA CRASSAFORMIS																				R										
GLOBOROTALIA MENARDII (s.l.)																														R
WATER ZONES	COASTAL WATER OF ARGENTINA				MIXED WATER						COASTAL WATER OF SOUTH BRAZIL																			

TABLE 2. Planktonic Foraminifera found in vertical samples (R/V Melville, 1972). Specimens number: R (rare) < 5, C (common) = 6-24, A (abundant) = 25-49, P (predominant) > 50.

Vertical Sample Number	7	16	17	18	19	25	27	26	28
GLOBOQUADRINA PACHYDERMA (f. superficiaria)	R	R	R						
GLOBIGERINA BULLOIDES (f. trilocularis)	R		R	R	R				
GLOBOROTALIA INFLATA		R	P	P	C				
GLOBOROTALIA TRUNCATULINOIDES			C	C	C	C			
GLOBOROTALIA SCITULA			C	C	C		R		
GLOBOROTALIA HIRSUTA			C	C	C		R		
GLOBOROTALIA CRASSAFORMIS						R	R		
GLOBIGERINOIDES RUBER (f. alba)			C	A	A	A	C		
GLOBIGERINOIDES RUBER (f. rosea)			A	A	P	P	C		
GLOBIGERINOIDES RUBER (f. elongata)			C	R	C				
HASTERIGERINA PELAGICA			R	R	R	A	A		
GLOBIGERINELLA AEQUILATERALIS (f. involuta)			R	R	R	C	C		
GLOBIGERINOIDES TRILOBUS (f. typica)			A	C	P				
GLOBIGERINOIDES TRILOBUS (f. sacculifera)			C			A	R		
GLOBIGERINOIDES CONGLOBATUS			R						
GLOBIGERINA RUBESCENS			R	R	C	R			
GLOBOQUADRINA DUTERTREI (f. eggeri)					R				
GLOBOQUADRINA DUTERTREI (f. typica)				R		R	R		
GLOBOQUADRINA PACHYDERMA/G. DUTERTREI			C						
GLOBIGERINA HEXAGONA			R			R			
GLOBIGERINA CALIDA			R			R			
GLOBOROTALIA MENARDII (s.l.)			C	R	C	P	C	R	R
CANDEINA NITIDA						R			
GLOBIGERINITA GLUTINATA			C	R	R	A	C		
WATER ZONES	COASTAL WATER OF ARGENTINA		MIXED WATER		SUBTROPICAL WATER		COASTAL WATER OF BRAZIL		

Globoquadrina pachyderma (Ehrenberg), *forma superficiaria* Boltovskoy, 1971, *In:* Funnell and Riedel, The Micropaleontology of Oceans, p. 281.

Globorotalia crassaformis (Galloway and Wissler) = *Globigerina crassaformis* Galloway and Wissler, 1927, J. Paleont., v. 1, p. 41, pl. 7, fig. 12.

Globorotalia hirsuta (Orbigny) = *Rotalia hirsuta* Orbigny, 1839, *In:* Barker-Webb et Berthelot, Hist. Nat. Iles Canaries, "Foraminifères", v. 2, pt. 2 Zool., p. 131, pl. 1, figs. 37-39.

Globorotalia inflata (Orbigny) = *Globigerina inflata* Orbigny, *Ibidem*, p. 134, pl. 2, figs. 7-9.

Globorotalia menardii (Orbigny) = *Rotalia menardii* Orbigny, 1826, Ann. Sci. Nat., Sér. 1, v. 7, p. 273, no. 26, Mod. 10.

H Globorotalia menardii (Orbigny), *forma typica* (Orbigny), *ut supra*.

H Globorotalia menardii (Orbigny), *forma tumida* (Brady) = *Pulvinulina tumida* Brady, 1884, Rept. Voy. "Challenger", Zool, v. 9, p. 692, pl. 103, figs. 4-6.

Globorotalia scitula (Brady) = *Pulvinulina scitula* Brady, 1882, Roy. Proc., v. 11 (1880-1882), no. 111, p. 716.

Globorotalia truncatulinoides (Orbigny) = *Rotalia truncatulinoides* Orbigny, 1839, *In:* Barker-Webb et Berthelot, Hist. Nat. Iles Canaries, "Foraminifères", v. 2, pt. 2, p. 132, pl. 2, figs. 25-27.

Hasterigerina pelagica (Orbigny) = *Nonionina pelagica* Orbigny, 1839, Voy. Amér. Mérid., v. 5, pt. 5, "Foraminifères", p. 27, pl. 3, figs. 13-14.
Orbulina universa Orbigny, 1839, *In:* de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 3, pl. 1, fig. 1.

PLANKTONIC FORAMINIFERAL ASSEMBLAGE—The distribution of the planktonic foraminiferal species is shown in Tables 1 and 2. They are arranged according to their tolerance of high temperatures or their penetration to the north (Boltovskoy, 1969; 1978; Bé and Tolderlund, 1971; and Lena and Watanabe, in press). In the samples analyzed, 4 groups of species were distinguished:

1) Cold-temperate water species: *Globoquadrina pachyderma (forma superficiaria), Globigerina bulloides, Globorotalia truncatulinoides, G. scitula* and *G. inflata.*

2) Warm-temperate water species: *Globorotalia hirsuta* and *G. crassaformis.*

3) Warm water species: *Globigerinoides ruber, Hasterigerina pelagica Globigerinella aequilateralis, Globigerinoides trilobus, G. conglobatus Globoquadrina dutertei, Globigerina hexagona, G. calida, Globorotalia menardii* and *Candeina nitida.*

4) Cosmopolitan species: *Globigerinita glutinata.*

WATER ZONES—The following water zones were recognized based on the distribution of the planktonic foraminifera collected (Fig. 2): a) Coastal Water Zone of Argentina (Subantarctic water modified by its proximity to the coast). In this type of water the foraminiferal fauna consisted of cold-temperate species in a low frequency (generally 1 specimen/sample); b) Mixed Water of the Subtropical/Subantarctic Convergence Zone. The planktonic foraminiferal fauna consisted mostly of warm and warm-temperate species mixed with some cold-temperate species; c) Subtropical Water Zone. This zone is characterized by warm and warm-temperate species. The presence of *Globorotalia scitula* and *G. truncatulinoides* in vertical samples, number 25 and 27 is an exception and can be explained as the result of subantarctic water upwelling (E. Boltovskoy, 1970); d) Coastal Water Zone of South Brazil (Subtropical water mixed with water coming from the south and modified by its proximity to the coast). Only a few warm water species were found in this area.

The hydrological results of our paper are similar to those previously obtained from foraminiferal data (Boltovskoy, 1959, 1966, 1970, 1978; Lena, 1975 and Lena and Watanabe, in press).

We thank E. Boltovskoy and R. L. Turner for reviewing this paper and D. D. Looney for helping in preparing this manuscript.

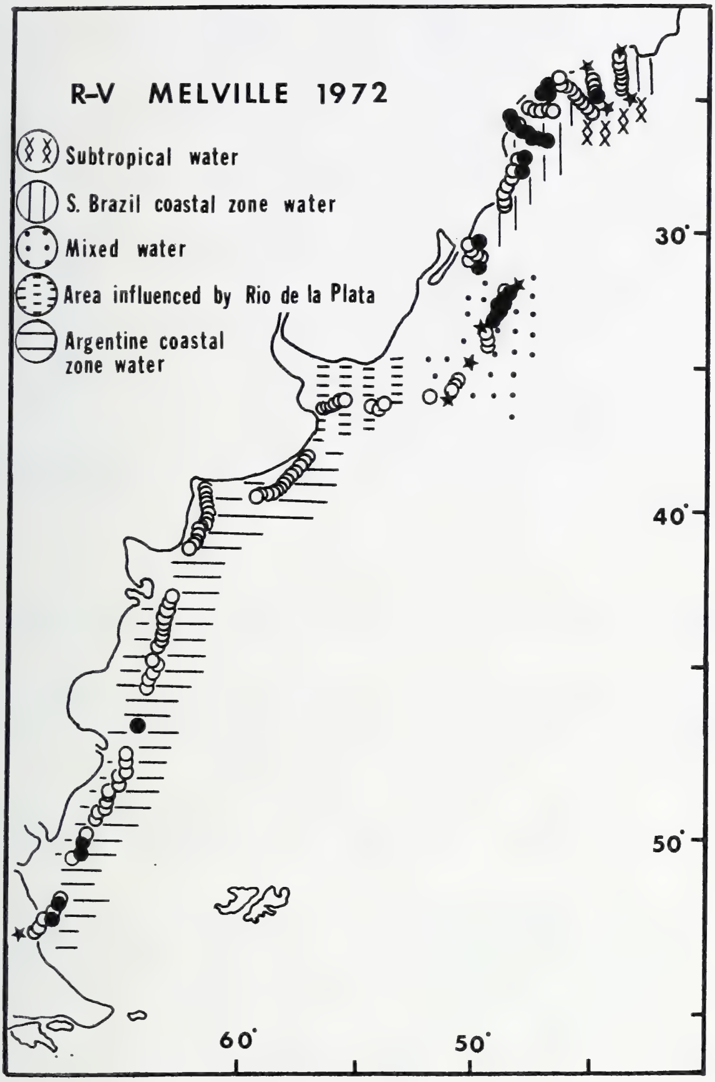
R-V MELVILLE 1972
Subtropical water
S. Brazil coastal zone water
Mixed water
Area influenced by Rio de la Plata
Argentine coastal zone water
30°
40°
50°
60°
50°

Fig. 2. Surface water zones determined on the basis of planktonic foraminiferal data during R/V Melville (1972) cruise in the southwest Atlantic.

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PROBABLE ESTABLISHMENT AND RANGE EXTENSION OF THE SPOTTED TILAPIA, *TILAPIA MARIAE* BOULENGER (PISCES: CICHLIDAE) IN EAST CENTRAL FLORIDA—*M. R. Clark*, Harbor Branch Foundation, Inc., RR 1, Box 196, Fort Pierce, Florida 33450.[1]

Abstract: *Juvenile* Tilapia mariae *were collected in southeastern Brevard County, Florida. A description of the area, probable methods of introduction, and reasons for probable establishment, are given.*

The introduction of the spotted tilapia, *(Tilapia mariae)* in Dade County, Florida was reported by Hogg (1974). Later, Hogg (1976) reported the establishment of this species in canals and ponds of Dade County. Courtenay and Hensley (1979) recently reported the range expansion of spotted tilapia to Broward and Collier counties, Florida (Fig. 1).

Tilapia mariae was recently collected at spillway S-157 in the Fellsmere Canal, Brevard County, Florida on 17 September 1979. (Fig. 1). This spillway is the last in the Fellsmere Canal before it enters the north fork of Sebastian Creek. Seventy specimens were collected above the spillway; 1 specimen was collected below the spillway (see Table 1), approximately 150 m west of the confluence with C-54 Canal and north fork of Sebastian Creek. Specimen ranged from 11-37 mm standard length ($\bar{x}$ = 24.1 mm SL). Subsequent collections in October, November, and December yielded additional specimens in salinities up to 4%, determined with use of American optical refractometer (see Table 1). All collections were made with a 3 m seine

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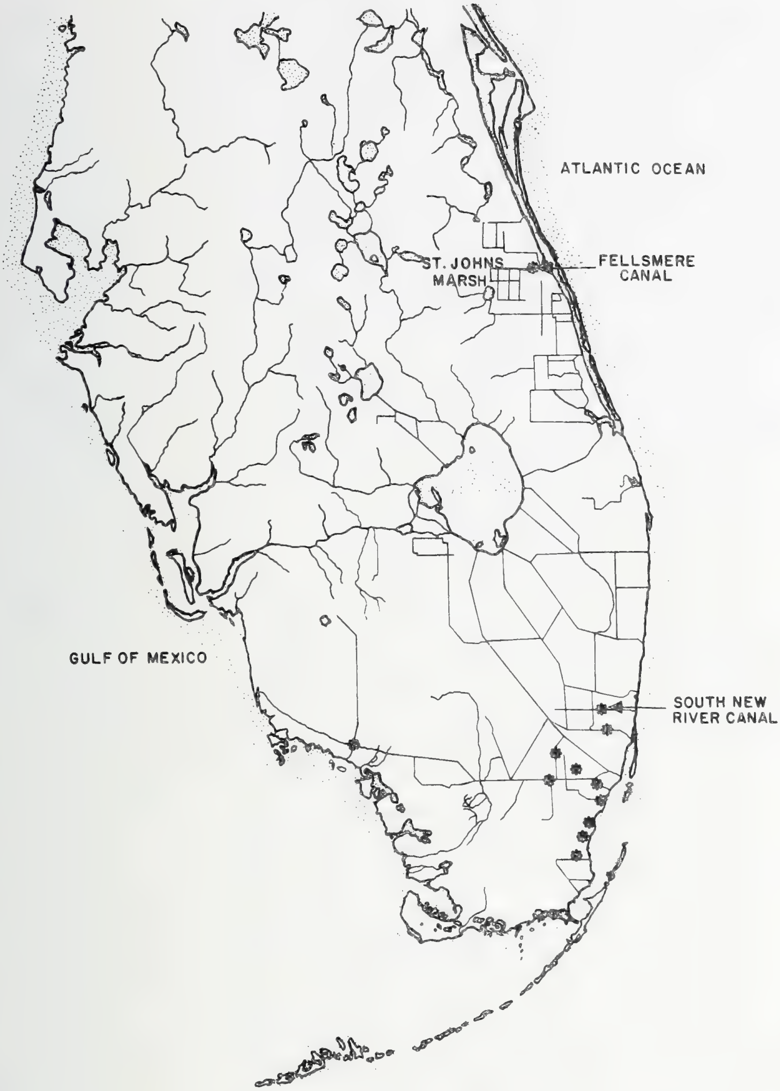

Fig. 1. Map of southern Florida showing collection sites of *Tilapia mariae*.

net. Specimens were deposited in the Indian River Coastal Zone Museum (IRCZM 107:5295, 107:5296, 107:5297, 107:5442, 107:5443, and 107:5444).

These collections extend the range of *T. mariae* approximately 168 km north of the New South River Canal in Broward County (Courtenay and Hensley, 1979) to extreme southern Brevard County. The Fellsmere Canal connects with an extensive agricultural and flood control canal system extending throughout Indian River County, draining the southeastern portion of the St. Johns River Marsh. This canal flows into C-54 canal and the

TABLE 1. Collection data for juvenile *T. mariae* in Fellsmere Canal, Brevard County, Florida.

Date	No. Specimens Above Spillway	Size Range SL (mm)	Sal °/oo	Temp °C	No. Specimens Below Spillway	Size Range SL (mm)	Sal °/oo	Temp °C
17 Sept 79	70	11-37	0.0	28.0	1	21	0.0	28.0
22 Oct 79	2	31-37	0.0	26.0	—	—	—	—
16 Nov 79	1	38	0.0	20.0	3	24-27 mm	2.0	21.0
19 Dec 79	—	—	—	—	2	28-29 mm	4.0	18.0

north fork of Sebastian Creek. The latter stream flows into the Indian River lagoon creating a tidal brackish stream with red mangrove *(Rhizophora mangle)* lining the shore at the mouth and gradually replaced by para grass *(Panicum purpurascens)*, cattail *(Typha)*, and willow *(Salix)* near the spillway. This tropical estuary may allow the spotted tilapia to occupy its preferred native habitat of brackish water (Courtenay and Hensley, 1979).

Tilapia mariae was usually collected in para grass growing on the canal banks and into the water. Water net *(Hydrodictyon)* was found among the under water stalks of para grass. Examination of 6 stomachs and intestines, from the September collection showed approximately equal amounts of unidentifiable algae, plant matter, and the diatom *Biddulphia (Cerataulus) laevis*.

Prior to the September 1979 collection of *T. mariae*, the study area had been sampled monthly since January 1979. Hurricane David passed over the study area on 2 September 1979. Two weeks of heavy rain followed. Data obtained from National Oceanic and Atmospheric Administration, Vero Beach weather station (23 km south of the collection site) showed 32.56 cm of rain fell in the area during 1-15 September 1979.

It was first assumed that spotted tilapia juveniles escaped, from 1 of the many fish hatcheries located in the Fellsmere area (Indian River County), 11 km to the southwest of the collections site, into the canal system during the period of heavy rain. However, because possession of *T. mariae* has been banned in Florida since 1974 (Frank Morello, Florida Game and Freshwater Fish Commission, pers. comm.), escape from a fish farm at this time appears unlikely. Introduction of *T. mariae* into the local fish fauna apparently took place before 1974 when the Florida Games and Freshwater Fish Commission applied ichthyocides to fish hatchery ponds containing tilapia (Art Wielding Jr., Riverview Water Gardens, pers. comm.). Although adults have not been collected, it is possible that permanent breeding populations occur in canals adjacent to existing and historical fish hatcheries in the Fellsmere area. Apparently the spotted tilapia is established in the canal systems of northwestern Indian River County, and has now spread to southeastern Brevard County and into tidal brackish waters in the north fork of Sebastian Creek.

ACKNOWLEDGMENTS—I gratefully acknowledge the assistance of R. Grant Gilmore and Philip A. Hastings in field work and review of this manuscript. Thanks also to Robert A. Gibson for identification of the diatoms, Dannie A. Hensley for confirming the identification of *T. mariae* and Walter R. Courtenay for suggesting the writing of this note. This is Contribution No. 215, Harbor Branch Foundation, Inc.

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LIMNOLOGICAL CHARACTERISTICS OF EUTROPHIC LAKE ISTOKPOGA, FLORIDA

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ABSTRACT: *A limnological investigation of Lake Istokpoga, Highlands County, Florida, and its major tributary streams was conducted during October, 1976 through June, 1977. Significant loading of the lake with nitrogen and phosphorus by the influent streams was discovered. Planktonic primary productivity in the lake was high, with an average carbon-fixation rate of 0.8 gm/m*^{3}*/day. Nutrient enrichment bioassay experiments were conducted several times during the study period with seasonably variable results indicated. Generally speaking, primary productivity in the lake appeared to be phosphorus-limited. Most of the data indicated that the lake was eutrophic.*

MANY areas of Florida are experiencing extremely rapid population growth, and this growth is placing a very heavy burden on the water resources of the state. Water is in great demand for numerous irrigation projects, industrial and recreational uses. As a result, many Florida lakes have become eutrophic. These lakes have been studied little (Sheffield and Kuhrt, 1970; Shannon and Brezonik, 1972; Cowell, 1975; Davis and Marshall, 1975; Milleson, 1978). In this report, I discuss the results of a comprehensive limnological investigation of Lake Istokpoga, which provides a significant component of the Lake Okeechobee drainage basin. Also discussed are the results of nutrient enrichment bioassay experiments.

THE STUDY AREA—Lake Istokpoga is located in Highlands County, south-central Florida (Fig. 1) just east of the Lake Wales sand ridge. It is the fifth largest in Florida, with a surface area of approximately 112 km^2 and a drainage basin of about 1700 km^2 (Milleson, 1978). The lake is shallow with an average depth of 1.6 m with surface water level regulated between 11.5 and 12.1 m above msl. The stained water of the lake is derived primarily from 2 major influents: Josephine Creek, which carries water from over 30 Lake Wales Ridge lakes to the west, and Arbuckle Creek, which drains a large agricultural tract to the north. The primary land use in the basin is agricultural, with citrus groves, improved pasture, and truck farming dominating. Hence, heavy demand is made on water supplies in the area for irrigation of crops. The major effluents are canals. Some water flows east through the Istokpoga Canal to the Kissimmee River, but the major outlet is controlled through Canal C-41A, to the Indian Prairie and Harney Pond canals and finally to Lake Okeechobee. The Istokpoga drainage basin contributes between 10 and 15% of the total flow into Lake Okeechobee (Davis and Marshall, 1975).

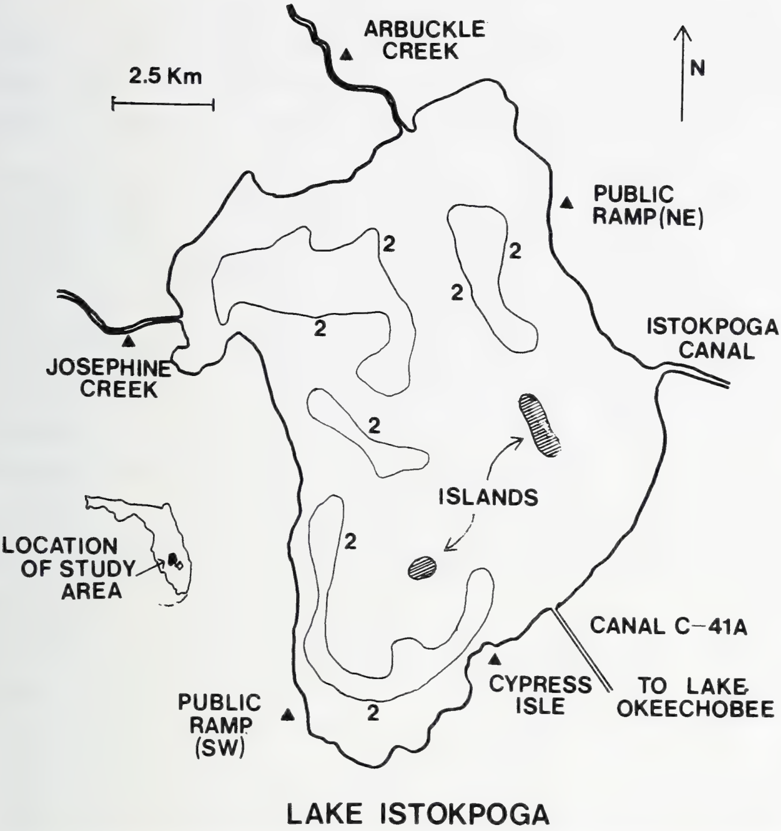

Fig. 1. Map of Lake Istokpoga showing its approximate location, 2-meter depth contours, and sample site locations (▲).

Materials and Methods—Samples for physicochemical analyses were taken just beneath the water's surface approximately monthly beginning in October, 1976 and ending in late June, 1977, from 3 locations around the lake and 2 influent streams. Due to the very shallow depth of the lake, an essentially homogeneous water column was assumed. Sample site locations are in Fig. 1. All samples were collected between 900 hr and 1200 hr. Temperature, pH, and specific conductance measurements were made in the field. Samples for dissolved oxygen were fixed in the field with the first 2 Winkler reagents. Samples for alkalinity, $NH_4^+ - N$, NO_2^-, $NO_3^- - N$, and P were taken to the laboratory on ice in a dark box. Standard analytical procedures were employed in chemical analyses (*Standard Methods*—American Public Health Association, 1975). Dissolved oxygen was determined by the azide modification of the Winkler method; alkalinity by titration with .02 N H_2SO_4. Various forms of N and P were determined by colorimetric procedures: $NH_4^+ - N$ by direct Nesslerization; $NO_3^- - N$ by cadmium reduction to $NO_2^- - N$ followed by diazotizing with sulfanilamide and coupling with

N—(1-naphthyl)—ethylenediamine; PO_4^{-3} – P by reduction of the molybdophosphoric acid with stannous chloride preceded by persulfate digestion in analysis for organically bound and condensed forms. Samples analyzed for N, inorganic-P and total dissolved-P were first filtered with 0.45 μm membrane filters.

Primary productivity estimates were made by determining rates of uptake of ^{14}C by plankton (Lind, 1974; Hall and Moll, 1975); samples of water were placed in 300 ml BOD bottles into which were injected 5-10 μCi of ^{14}C as $NaH^{14}CO_3$. These bottles were incubated for 2 hr near the shoreline with water just covering the bottles. Dark fixation rates were also determined. All incubations were carried out between the hours of 1000 hr and 1300 hr. At the end of the incubation period, the bottles were placed on ice in a dark box for transport to the laboratory. Twenty-100 ml were gently filtered through 0.45 μm millipore filters which were then dried and placed in glass scintillation vials. Filters were covered with a toluene-based fluor and counted with a Packard (Model 3320) liquid scintillation spectrometer.

Total inorganic carbon was estimated by performing acid and base titrations in the field on subsamples of water used in the ^{14}C experiment (Lind, 1974).

Nutrient enrichment bioassay experiments were conducted 4 times during the year using surface water from the lake. Water was passed through a plankton net (No. 20 mesh nylon) to remove zooplankton and placed in 3-liter glass columns (anaerobe jars). The following enrichment regime was ultimately employed with duplicate systems set up for each treatment: Controls; .05 mg/l PO_4^{-3} – P; .05 mg/l P and 0.75 mg/l NO_3^- – N; 0.1 mg/l P and 1.5 mg/l N; .05 secondary sewage effluent. Enrichment with N alone was discontinued from the experimental regime when no response was seen in early experiments.

The sewage effluent was filtered and frozen until use. This was diluted to .05 effluent with lake water when setting up cultures. The dilution brought the concentrations of N (NH_4^+ and NO_2^-, NO_3^-) and P (ortho-PO_4) to approximately 1.0 and 0.27 mg/l, respectively. The cultures were maintained at room temperature of 25-27°C for 4 da. Light was provided by three 40-watt Daylight fluorescent bulbs giving approximately 3190 ergs/cm^2/second at wavelengths of 380-750 nm. The cultures were gently aerated to prevent settling of plankton. Samples were collected on Day 2 of the experiment and analyzed for chlorophyll *a* and on Day 4 for determinations of chlorophyll *a* and C-fixation rates. C-fixation rates were determined by incubating samples of the culture jars for 2 hr using the same lighting system described above and employing similar procedures noted earlier with respect to estimating ^{14}C-productivity.

Significant differences ($p < .05$) among data sets were determined using "t" tests.

Physicochemical data—Table 1 summarizes the physicochemical characteristics of surface water of Lake Istokpoga and its 2 major tributary streams. No significant differences were observed among the 3 lake sample sites with regard to any physicochemical characteristic. However, when compared with the influent streams, the lake showed some significantly different nutrient concentrations. The 2 streams had significantly higher NO_2^-, $NO_3^- - N$ concentrations than did the lake sites, although $NH_4^+ - N$ levels in the lake were significantly higher than those in Josephine Creek and not significantly different from those in Arbuckle Creek. With respect to TDP (Total Dissolved Phosphorus), Arbuckle Creek had significantly greater concentrations than did the lake, but Josephine Creek did not. The 2 streams were significantly different with regard to $NH_4 - N$, NO_2^-, $NO_3^- - N$, and TDP. Clearly, the influent streams carry significant concentrations of N and P to the lake. Approximately half of the TDP in the influent streams was ortho-PO_4, while in the lake generally only trace amounts of ortho-PO_4, were found.

A comparison of the nutrient concentrations of the influent streams with those of the lake sites over the course of the sample period is in Fig. 2. Lake site data points represent means of the 3 sample sites. The significant differences in NO_2^-, $NO_3^- - N$ among the streams and lake sites were evident throughout the year. Seasonal trends were not particularly obvious although the lake sites generally showed low N and P concentrations in late spring, while the influents showed irregular peaks. Peaks in NO_2^-, $NO_3^- - N$ in Josephine Creek and TDP in Arbuckle Creek coincided with the beginning of the rainy season in early summer.

PRODUCTIVITY AND CHLOROPHYLL *a*—Planktonic primary productivity (expressed as carbon-fixation) and Chl *a* standing crop for the 3 lake sample sites are shown for the sampling period in Fig. 3. Beginning in January and lasting to the end of the sampling period, the Ramp (SW) site showed significantly higher C-fixation rates than did the other sites. The general trend seen was one of increasing C-fixation at all sites throughout the winter and early spring with the obvious exception of the April data points. The peak C-fixation observed in the lake occurred in June at the Ramp (SW) site, approximately 210 mg C/m^3/hr. The most obvious feature in the pattern of productivity during the sample period was the distinct decline observed at all sites in April. A similar decline was also seen in Chl *a* at the same time. Seasonal trends in Chl *a* were not evident.

An overall mean in C-fixation (all sites and throughout the sample period) for the lake of approximately 97.4 mg/m^3/hr was calculated. If half of the daily primary productivity is assumed to occur between 1000 and 1400 hr (Vollenweider, 1969), an estimate of daily surface productivity of approximately 0.8 gm/m^3/day or 292 gm/m^3/yr is possible.

NUTRIENT ENRICHMENT—Figure 4 shows the result of nutrient enrichment experiments conducted 4 times during the study period. Carbon-fixation rates after 4 days of incubation are compared with carbon fixation rates at the beginning of the experiment, and Chl *a* concentrations are shown for days 0, 2, and 4 of the experiment. A very different response pattern was

TABLE 1. Physicochemical characteristics of surface water of Lake Istokpoga and major influent streams[1]

Sample Site	Temp. (°C)	Dissolved oxygen (mg/l)	pH	Specific conductance (μmhos/cm)	Alkalinity (mg $CaCo_3$/1)
Public Ramp (S.W.)	20.9 (14.0-28.9)	7.46 (6.90-8.60)	6.60 (6.20-6.69)	143 (130-158)	7.90 (3.70-11.80)
Cypress Isle	20.7 (14.0-27.5)	6.87 (5.80-9.61)	6.49 (6.00-7.00)	131 (110-155)	6.40 (3.10-10.80)
Public Ramp (N.E.)	20.8 (14.0-27.5)	6.93 (4.10-9.20)	6.43 (6.24-6.78)	145 (130-160)	8.60 (6.90-11.73)
Josephine Creek	20.1 (14.5-25.5)	7.45 (6.32-8.20)	6.46 (6.20-6.90)	146 (120-165)	13.86 (8.90-19.80)
Arbuckle Creek	21.1 (15.0-27.0)	6.60 (4.44-8.31)	6.28 (5.95-6.60)	132 (100-147)	9.42 (5.05-11.60)

Sample Site	NH_4^+-N (mg/1)	NO_2,NO_3-N (mg/1)	Total dissolved-P (mg/1)
Public Ramp (S.W.)	0.84 (0.48-2.05)	0.013 (<.004-.027)	.034 (.023-.037)
Cypress Isle	1.04 (0.48-2.00)	0.005 (<.004-.023)	.037 (.021-.063)
Public Ramp (N.E.)	0.90 (0.30-0.80)	0.005 (<.004-.011)	.048 (.032-.105)
Josephine Creek	0.58 (0.30-0.80)	1.040 (0.56-1.88)	.050 (.022-.107)
Arbuckle Creek	0.89 (0.56-1.35)	0.160 (0.06-0.39)	.070 (.038-.094)

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[1] Mean values for the period Oct. 1976-July 1977; range of values in parentheses.

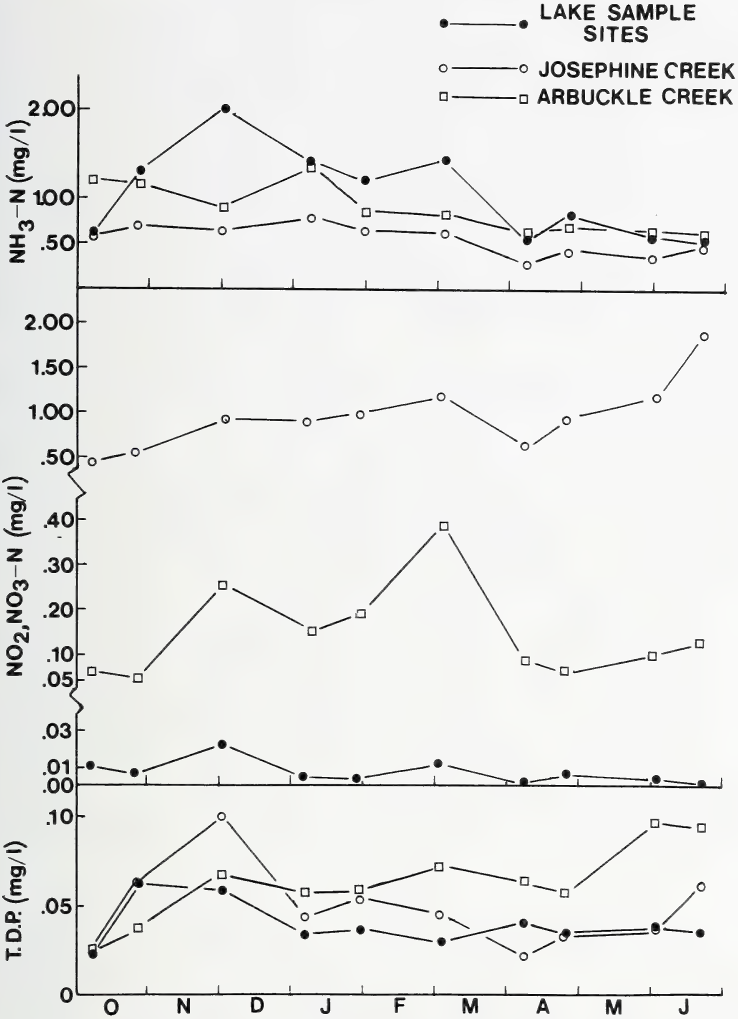

FIG. 2. Seasonal variations in NH_4^+ – N, NO_2^-, NO_3^- – N and T.D.P. (Total Dissolved Phosphorus) in Lake Istokpoga and 2 major influent streams. Lake data points represent means of 3 sample sites.

seen in the November experiments as compared with February and June. Indeed, a second November experiment was conducted because of the highly unexpected responses seen in the November 8 experiment. In both November experiments no type of enrichment resulted in Day 4 C-fixation levels reaching above the initial value. However, cultures receiving N and P in combination and .05 sewage effluent did show a significantly lower decline in C-fixation from the initial value than the controls in the November 29 experiment. The Chl *a* data showed a significant increase above control levels in the N + P enriched cultures.

In February and June a very different pattern was seen. In both experiments, C-fixation rates were significantly increased above control levels in all but one experimental culture. In the .05 S experimental, in the June experiment, no enrichment above initial levels was seen although no decline comparable to the controls was evident either. Doubling the concentrations of N and P in combination was found to significantly increase C-fixation over other experimental enrichments. The results in terms of Chl *a* data for the February and June experiments paralleled the C-fixation data except that in the June .05 S experimental Chl *a* concentrations reached levels comparable to those of the P and N + P enriched cultures, whereas the C-fixation rates did not.

Generally, the algae which dominated the enriched cultures were also abundant in the lake phytoplankton. These included in particular the blue-green, *Microcystis*, the desmid, *Pediastrum*, and the diatom, *Tabellaria*.

Discussion—Physicochemical data from the 3 lake sample sites indicated a well-mixed body of water. Undoubtedly, the large surface area in conjunction with a shallow depth facilitates wind-generated mixing. The influent streams are significant contributors of nutrients to the lake where high primary productivity levels are the result.

From October through April was dry as apparently was typical through the mid-1970s (Milleson, 1978). It is likely that irrigation projects contributed significant amounts of nutrients in runoff during that period (see Fig. 2, the Arbuckle Creek NO_2^-, $NO_3^- - N$ data). Relatively high concentrations of N (Josephine Creek, $NO_2^- - NO_3^- - N$ data) and P (Arbuckle Creek, TDP data) were also seen at the beginning of the wet season when volume of runoff increases (Fig. 2).

The significantly higher primary productivity of the Ramp (SW) site compared with the other lake sites reflected higher Chl *a* concentrations which in turn might have been due to turbulent water at that site. Typical winds during winter and spring were northerly to northeasterly at 15-20 knots resulting in very turbid water in the southern and south-west reaches of the lake. The resulting higher turbulence at the southern reaches of the lake may have kept algae suspended in the water column which would otherwise settle out. Indeed, the high planktonic C-fixation rates seen at all the lake sites during the late winter and spring months may have been due to water turbulence. Strengthening this hypothesis are the April data which were collected on an unusually calm day for the period. A dramatic decrease in both C-fixation and Chl *a* was seen at all sites (Fig. 3) and less turbid water was particularly evident in that set of samples.

The nutrient enrichment experiments indicated that primary productivity in the lake was limited primarily by P. No explanation is readily available for the relative nonresponse in the November experiments (Fig. 4). Seasonal differences in response of ambient algal populations may have been responsible. Such seasonal differences from nutrient enrichment bioassay experiments have been demonstrated (Storch and Dietrick, 1979). These

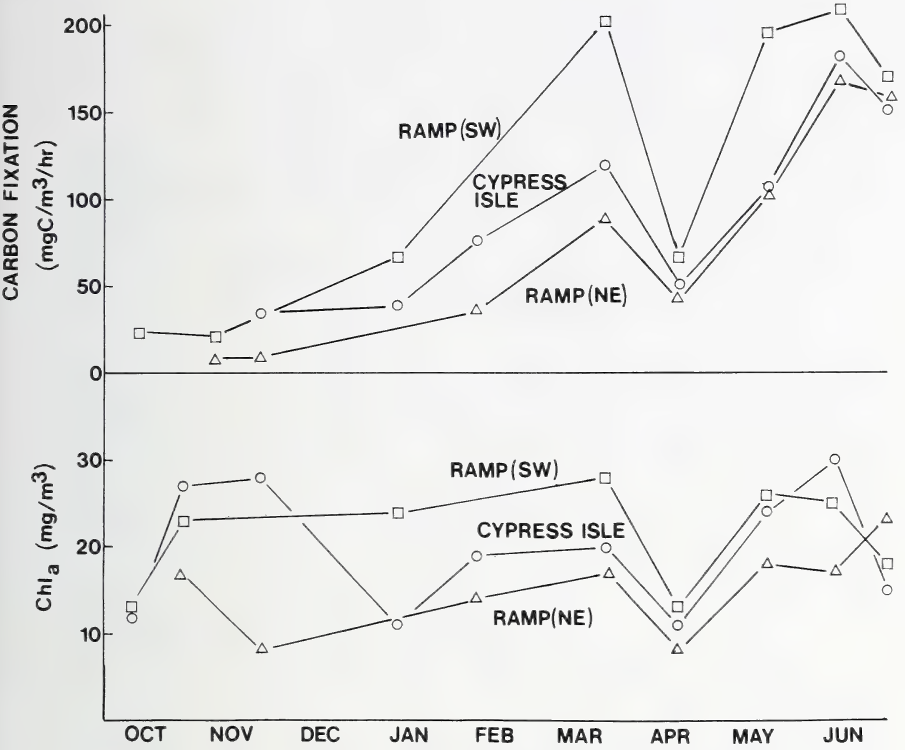

FIG. 3. Seasonal rates of planktonic primary production and chlorophyll *a* concentrations of surface water at 3 sites on Lake Istokpoga. Sites are 2 public access ramps and Cypress Isle Fishing Camp.

results do indicate the advisability of performing enrichment bioassays on a seasonal basis.

If the Chl *a* data for the enrichment experiments are examined (Fig. 4), some evidence is available to suggest that N is at least secondarily limiting. In the cultures enriched with both N and P, an immediate response is seen between Day 0 and Day 2 in Chl *a*, whereas in cultures to which only P was added, a delayed response in Chl *a* concentration is seen (from Day 2 to Day 4). This might indicate an availability of some N midway through the experiment in those cultures. Perhaps during the course of algal succession in laboratory cultures turnover of cells provides sufficient N to permit an enrichment response to P addition alone. Clearly, the duration of nutrient enrichment experiments must be an important consideration in experimental design (Gerhart and Likens, 1975).

Taken as a whole, the data point to Lake Istokpoga being a eutrophic system. Milleson (1978) also concluded that Lake Istokpoga was eutrophic. Primary productivity, Chl *a* and nutrient concentrations all would seem to justify such a classification. Some of these data compare well with data

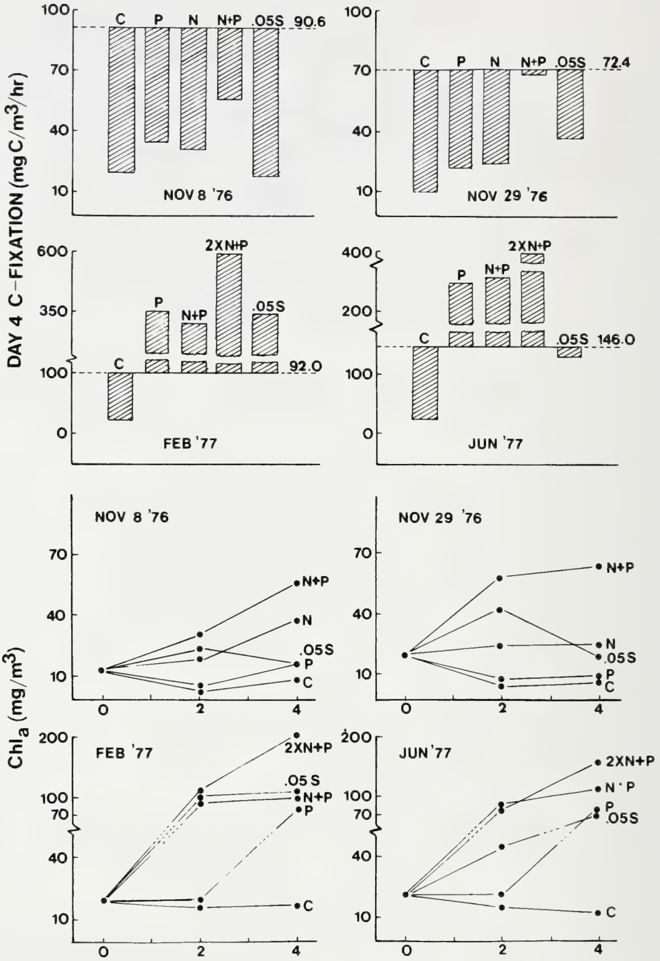

FIG. 4. Response to enrichment by Lake Istokpoga water. Day 4 C-fixation rates are compared with Day 0 rates and chlorophyll *a* concentrations are given for Days 0, 2, and 4. The enrichment regime was as follows: C = controls; P = .05 mg/l PO_4^{-3} – P; N = 0.75 mg/l NO_3^- – N; N & P = .05 mg/l P and 0.75 mg/l N; 2X N & P = .10 mg/l P and 1.50 mg/l N; and .05S = .05 secondary sewage effluent.

found for eutrophic colored lakes in northern Florida by Shannon and Brezonik (1972). The shallow nature and large surface area of the lake is largely responsible for the lack of any significant thermal stratification during the year. This feature undoubtedly helps prevent some of the undesirable aspects commonly associated with eutrophic systems (e.g., an anoxic hypolimnion and large accumulations of unoxidized organic matter). It must be assumed, however, that much of the endogenous productivity that does occur in the lake is exported downstream to Lake Okeechobee. As noted earlier, Istokpoga contributes a significant amount of water to Lake Okeechobee and obviously any efforts made to deal with the problems of Okeechobee should be addressed to the Istokpoga basin as well.

ACKNOWLEDGMENTS—I am deeply indebted to Dr. James N. Layne and the staff of the Archbold Biological Station, Lake Placid, Florida, for their generous support of this project in the form of laboratory facilities and encouragement. Particular thanks are due Ms. Jerre Stallcup, who assisted with some of the field and laboratory work.

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SETTING SUPERVISION GOALS: TOWARDS AN END TO THE NONSYSTEM

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Abstract: *From early in this century, those involved in the Criminal Justice System concluded that it should be approached as a discipline and subject to the empiricism of cause and effect. However, coupled with certain erroneous presumptions, the failure to adequately define the problem at the outset has prevented agreement and conclusion on objectives, and efforts undertaken seem at times to aggravate the crime problem. Construction of an etiological typology of criminal offenders uncovers the real objectives for a Criminal Justice System and shows what strategies should be developed. A typology recognizing crime as a manifestation of normal, conformist conduct as well as deviant conduct leads to the conclusion that there are multiple objectives to be achieved by a Criminal Justice System. These objectives, then, show the need for strategies of support, management, deterrence, retribution, and protection.*

The theme of an article published by the authors in 1971 was that corrections could be characterized as an endeavor where a constant proliferation of insightful solutions had been, and are being, offered to solve problems that had never really been defined (Unkovic and Kelton, 1971). The inevitable result of such policy would be the accumulation of a body of ignorance—or unknowledge. Applying this hard-won ignorance to the nonunderstood problem would yield progressively poor results at increasingly higher costs. Consequently, an examination of that social institution designated the Criminal Justice System reveals an intriguing contraption. Very little of it stems from the practical application of things learned through empirical research. Very much of it is the perpetuation of insightful plans from other eras. Modifications have occurred at times of emergency, when, another set of insights, then currently fashionable, has been rushed into the breach. Almost never have these insights been tested for validity, but, once incorporated into the system, they are never wholly discarded. Standing back then, to look at the system, one sees the vast geological strata of what has been termed "criminology." Everything that has ever been employed in corrections is still there as it continues its glacial meandering. Continuing in this tradition, criminologists and correctional leaders of our own era have put into motion a proliferation of insightful solutions to the problem—the problem again being vaguely conceptualized rather than defined.

We had proposed that if this pattern ever were to be reversed, a beginning was needed, and this beginning would be to define the problem. This was seen as a task of extreme complication when one examined the data in contraposition to previous traditional beliefs. Behaviorally, the labeled criminal appeared to be widely diverse in both manifestation and etiology. Awareness of this was heightened by the growing contemporary trend to see criminal behavior as a product of social situations rather than individual aberration or defection. Coinciding with this has been an equally haunting awareness that the empiricist idealism of the 19th Century was not going to yield the ultimate criminological truth or correctional solution. The scientific method of gathering and studying facts and data was apparently not going to isolate that final true factor or set of factors by which individual criminals could be identified and individual behavior reliably predicted.

The final reality to be faced is that "crime" may be very much closer to being a natural, normal phenomenon that "law." Crime—simply the doing and taking of what one wishes when and how one wishes—seems much closer to a natural state of affairs than law which requires to be built on (no one knows how many) eons of human social experiences. What we call crime exists simultaneously with creation but law is coerced. The group replaces the individual as the arbiter of what will be done by whom and how it will be done and when (Gerber and McAnany, 1970). It now begins to appear that much of law violation is sociological in derivation (Chambliss, 1969). This is not as fundamental as it sounds and has nothing directly to do with such homilies as "poverty breeds crime." What is being referred to is the dawning realization of a belief that law is not absolute. Law for a long time had been absolute. This was accomplished, perhaps, by a prehistorical people employing a sociological *deus ex machina.* The leader of these people went to the doorstep of a heavenly kingdom and obtained from a diety a written and codified law. This became the ultimate absolute, and there is probably no legal system anywhere that does not similarly trace its legitimacy. If law loses this quality of the absolute, it becomes a thing to be obeyed or violated depending on circumstances. Undoubtedly, this loss of absolute quality can explain proportionately high crime in a society. Furthermore, when such belief and its ramification gains momentum, it may infiltrate the ranks of the legal functionaries of the society to the extent that systemic breakdown is imminent. For some societies, perhaps that is the contemporary condition. This, then can be said of the law. It is a truly sociological phenomenon—the efforts of people constrained to live in groups, selecting a type of group existence considered desirable and taking steps to perpetuate that scheme of existence (American Bar, 1968).

The goal of each person is fulfillment as an individual. The means to this goal is life in a group. Attempts to resolve the problem arising from this blatant paradox feature a codified law and "correctional system." When the law is absolute, the individual has no recourse but to accept the group mandate or suffer the stipulated fate for social defection. Depending on the singleness of its absolutism, this fate varied from degrees of rejection and ostracism to elimination (death). Absolute systems are currently under attack for legal codes that embody segments known as legislated morality. Critics desire that laws should address themselves only to those crimes against person or property. But the fact is that all laws are legislated morality (Caldwell, 1965). Certainly, crime against property presupposes morality in terms of the acquisition and tenure of private possessions—a principle not universally held and, in fact, losing as much support as it gains. As for crime against the person, this is a definite instance of legislated morality of relatively recent origin among men and deriving its main support from theological consideration. Certainly, what is natural in observable nature is that life is dependent on the exploitation of the vulnerable.

The purpose of the absolute system, then, is for people to live in accordance with a divine plan, no questions asked. Those who violate law are defectors and sinners whose point of view or reasons are invalid. They must repent, conform, or lose membership. In the nonabsolute system, people are to live rationally and any violation of law must be considered rationally. The law must be examined as well as the violator, and disposition of the violator must be made within a context that is nonpunitive. But if a nonabsolute system has individual expression as its ultimate goal, it must also realize that this guarantee to each individual is only viable to long as the group maintains its existence, for it is, whatsoever, no less a system of legislated morality than the absolute.

The only difference between the systems is that an absolute system has unquestioned mandate to preserve, protect, and perpetuate itself, whereas a nonabsolute system must decide, in effect, each time a law is violated whether the system is worth preserving. From the nonabsolute viewpoint, then, legal systems are temporal.

As might be suspected, no system is ever going to be devised that is totally absolute or totally temporal, but any given system is going to fall somewhere between absolute and temporal poles. In a system characterized by its absolute quality, we will see an attempt to regulate the individual and any conduct felt to be harmful to himself, others, or the system. In a system characterized by its temporal quality, we will see an attempt to regulate the conduct of groups, especially governmental, that are deemed harmful to individuals and individual conduct deemed tangibly harmful to others. Surely, in our times, we witness the phenomenon of legal-correctional systems struggling to determine their identity within this context. With equal assurance, we can expect, at all times, to find conflict to be an essential entity of any human, social effort—social efforts having no other purposes than to control behavior.

How, then, to define crime? If we were then to make a theoretical structure which embodied all of what we think we now know and at the same time could be used to meet the needs of vastly different legal and correctional systems, what would it be like in very brief form? It would consist of a criminal justice system with 3 basic functions: problem definition; program decision; and program execution (Rubin, 1963).

TYPOLOGY–PROBLEM DEFINITION—In the 1971 paper, we proposed that definition of the problem would come through the construction of a typological scheme that utilized the findings of eminent criminologists with modifications that seemed valid in the light of personal observations and experience in the field. We constructed such a typology, and it is presented here without commentary (Fig. 1). The terms employed are common to those familiar with such inquiries, and the scheme can, no doubt, be readily understood. Briefly, offenders are placed in the typology in accordance with the etiology of their crime. Crime as the property of the individual is deviant behavior in that it is conceptualized as the inability of an individual to cope with his environment. It is, in effect, a personal problem. Crime as the property of the group is conformist behavior in that it simply represents the individual attempting to pursue life in the same fashion as those he admires and respects. Crime in this sense is a social movement. As can be seen, this typology is easily used to define the problem in either absolute or temporal legal systems.

Court Sentence–program decision—In the American system, which can serve as an example, the Court sentence represents a decision made regarding the program to be followed with an adjudicated offender. This decision is properly made when based on knowledge of the goals of a criminal justice system in the face of the problem as it has been defined (Hoffman, 1975). Probation officers aid in defining the problem for the Court. Their presentence investigation is a compilation of documented facts from which a definition can be achieved. The Court may permit the probation officers to suggest the definition and make a recommendation as to the program that should be selected in an attempt to solve the problem. At any rate, a presentence investigation should reveal where a particular offender can be located in the typology presented. Sentencing, then, should represent an effort to define the problem presented by some offender and the selection of some available program that may provide a solution to the problem. Sentencing goals are related to the etiological factors that have been isolated in the typology. These goals are schematically presented in Fig. 2 in a device suggestive of one that might aid in making program decision.

Execution of Sentence–the program—Incarceration is one of the programs for achieving goals that can be decided upon after the problem has been correctly defined. Probation and parole supervision are other alternatives. Offenders from all sectors of the typology can be sentenced to either imprisonment or probation. Thus, the program goals of these two divisions of a correctional system are related and similar. For purposes of illustration, our further discussion will be confined to probation and parole supervision.

Much of the effort and time of theoreticians as well as pragmatists has been devoted to the process of "supervising" criminal offenders in the community. Despite continued and intense attention to this subject, it remains a nebulous and somewhat intangible concept. The report of the GAO, just released 21 October, 1977, emphasized that federal probation officers were conducting "supervision" of offenders on probation and parole without established objectives or goals or organized plans to achieve them (Comptroller General, 1977). In responding to this criticism, probation officers indicate that they are aware of their goals even though neglecting to articulate them. The probation officer desiring to articulate the goals of supervision upon surveying the literature and drawing from his experience may find that there are 5 general objectives from which to select (American Bar, 1970;

MENTAL ILLNESS	All the many ramifications which can only be designated by an M.D. includes psychopath* The Over-Inhibited Person (Jenkins-Hewitt)	Psychotic, Neurotic, Personality Defect	Psychological	CRIME AS THE PROPERTY OF THE INDIVIDUAL	DEVIANT
MENTAL DEFICIENCY	Designated by M.D. or valid documentary evidence - the defective delinquent	Primary Product of Inadequate Mental Endowment	Simple		
SOCIAL INCOMPE—TENCE & DEFICIENCY	The Over-Indulged Person The Unsocialized Aggressive (Jenkins-Hewitt) The Social Incompetent - no knowledge of "right or wrong" - lives by wits - crude petty stealing & aimless offenses simple criminal amateur (Tappan) psychologically "normal" but inadequate social endowment (Vold)	Wrong Training Poor or No Training	Criminality-Amateur (Tappan)		
MOMENTARY SOCIAL DEFECTION	*Catastrophic* - temporary psychological breakdown brought on by intense, unusual trauma *Situational* - often malum prohibitum *Marginal referrer* Anomie (Merton)	Members of the General Society	Circumstantial		
PERMANENT SOCIAL DEFECTION	Pseudo Social (Jenkins-Hewitt) religious, philosophical sectarian (Vold) conforming to the norms of a sub-culture, which norms are in violation of codified norms (law) enacted by political majority large social segment - members of a subculture - society within a society		Sub-Cultural	CRIME AS THE PROPERTY OF THE GROUP	CONFORMIST
PROFESS-IONAL ANTI-SOCIALISM	Racketeer - gangster The con man	Career Crime Fringe Types Prof. Crime	Criminal		

FIG. 1 Typology of criminal offenders.

	LOW IMPORTANCE	MODERATE IMPORTANCE	HIGH IMPORTANCE
PUNISHMENT AND DETERRENCE	XXX		
REMOVAL AND PROTECTION	XXX		
RETRIBUTION AND INTEGRITY		XXX	

HIGH IMPORTANCE	MODERATE IMPORTANCE	LOW IMPORTANCE	
XXX			AVOIDANCE OF INSTITUTIONAL EXPERIENCE
XXX			COMPELLED SOLUTION TO IDENTIFIED PROBLEM (REHABILITATION)
	XXX		CONSISTENCY AND AVOIDANCE OF DISPARITY

Fig. 2 Sentencing goal device that has been completed for a case where probation is indicated as an appropriate correctional program.

Dufee and Fitch, 1976; McBee, 1974). It must be pointed out that while each of these objectives is pertinent to each case, their importance will vary so that in any given case 1 or 2 can be selected for major emphasis. A case, then, can be characterized by the goal or goals that have been selected for emphasis (Stanley, 1976). The 5 apparent goals of supervision are discussed.

Supportive—Here, the probation officer has realistic expectations that the offender can make a total recovery from a criminal episode or experience and provides guidance, counsel, instruction, and example to support the offender in his recovery. Also included for emphasis of this goal would be those cases where criminal activity is mainly self-destructive or seemingly intended to punish others and stems from an impaired personality. The supportive role is emphasized with such offenders so long as his or her behavior remains within acceptable limits, thus enabling the probation officer to attempt reconstructive counseling and guidance.

Managerial—Here, the probation officer is aware of clearly defined needs or deficiencies of the offender that relate to or, at least, aggravate his or her recovery from criminal experiences. The probation officer uses supervision conditions, procedures, and sanctions to compel a solution to the identified problem. The probation officer refers the offender to a "delivery system," monitors progress and phases out criminal justice attention or increases it as needed.

DETERRENT—When the offender's involvement in criminal activity is becoming a pattern and is perhaps functional, the probation officer provides high visibility of the criminal justice system to restrain, guide, and counsel the offender so that he will be convinced that criminal activity is an error.

RETRIBUTIVE—Here, the probation officer recognizes the need for maintaining the integrity of the criminal justice system to others as well as general social deterrence and respect for the law. The probation officer provides high visibility of the retributive aspects of the supervision program.

PROTECTIVE—When the offender is recognized as being committed to a criminal career or has clear and threatening patterns of criminal or antisocial behavior, the probation officer emphasizes the surveillance-investigative aspects of the supervision program in order to make early detection of any future criminal activity and institute prosecutive action.

SUMMARY—There is a need for those employed or interested in what we call "criminal justice systems" to understand certain realities. These realities have to do with defining the problem, decision making, and achieving goals.

Defining the problem means understanding a wide range of origin for criminal conduct. While some criminal acts represent a person acting in a deviant way to strike out against his environment and others, some criminal acts represent an individual attempting to conform and cooperate with others to achieve commonly shared goals. This reality in regard to the origins of criminal behavior is best stated through the use of an offender typology.

If Court sentencing is expected to be a decision-making process in regard to finding a solution for a given crime problem, further realities must be understood. These realities involve the acceptance of a number of goals for a correctional system and an intelligent selection of priorities in view of these goals and the probability with which they might be reached.

With similar realism, programs for the execution of Court sentences must be attempted after valid definition of the problem and precise statement of the goals to be reached.

If all those factors are taken into consideration, our criminal justice system might evolve into something more than a nonsystem.

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HYGROPHILA POLYSPERMA (ACANTHACEAE) IN FLORIDA—

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ABSTRACT: *The Old World species, Hygrophila polysperma (Acanthaceae) is reported for the first time as naturalized in Florida. Synonymy, description, and distribution in Florida are given. The species is illustrated.*

RECENT field collections of *Hygrophila polysperma* (Roxb.) T. Anderson from Lee County, Florida, indicate that this exotic species has become naturalized in that area.

Hygrophila polysperma is indigenous to the East Indies. Reams (1953) reported the species as becoming established in lakes in Virginia when introduced, but doubtfully naturalized there. The species was first collected in Florida near Tampa in 1965 [*Wiggins 19184* (FLAS)], but remained misidentified as "*Dyschoriste* sp." until 1977 when the proper determination was made by Dieter C. Wasshausen, Smithsonian Institution. The occurrence of *H. polysperma* at the Tampa locality is best regarded as an escape from cultivation. Attempts to relocate the population have been unsuccessful.

The first collection of *H. polysperma* from Lee County, Florida, was made by the senior author in December 1979. Plants in the vegetative state were noted by the same author as early as May of the same year. The Lee County specimens were identified by *H. polysperma* by the authors and verified by comparison with the specimen collected from the Tampa locality. Subsequent collections have shown the species to be well distributed and established in Lee County.

Hygrophila polysperma belongs to the subfamily Ruellioideae, tribe Ruellieae, subtribe Hygrophilinae (Bremekamp, 1956). The genus

Hygrophila contains about 80 species which are distributed primarily in the Old World tropics with a few tropical American species (Long, 1970). *Hygrophila lacustris* (Schlecht.) Nees, indigenous to the southeastern United States, is the only other representative of the genus in Florida. *Hygrophila polysperma* and *H. lacustris* can easily be distinguished by habit and size. *Hygrophila lacustris* is typically an erect emergent frequently over 50 cm tall, while the emergent form of *H. polysperma* is prostrate and creeping, rarely over 10 cm tall. At anthesis *H. lacustris* has very distinct axillary verticels of flowers, while in *H. polysperma* the flowers are more or less hidden in crowded apical leaf axils. *Hygrophila lacustris* has a leaf length of 5-12 cm, capsule length of 8-12 mm, corolla length of 7-8 mm, and calyx length of 4-5 mm, while *H. polysperma* has a leaf length of 2-8 cm, capsule length of 4-6 mm, corolla length of 4-6 mm, and calyx length of 2-4 mm. *Hygrophila lacustris* is typically a marsh plant, while *H. polysperma* seems to prefer riverine habitats.

The flowers of all *Hygrophila* spp. are purple or bluish-white. Some authors (Eyles and Robertson, 1944; Correll and Correll, 1972) erroneously refer to the flowers of *H. lacustris* as being yellow. This misconception originates from the examination of dried material in which the normally bluish flowers have changed to a dull yellow color. The flowers of *H. polysperma* turn yellow upon drying as well.

It is likely that *H. polysperma* has been introduced into Florida via the aquarium plant industry because the species has been extremely popular with aquarium enthusiasts since its introduction into the market in 1948 (Axelrod, 1954; Brunner, 1973; Stodola, 1967). McLane (1969) supports this suspicion by presenting a list (which includes the entry, "Hygrophila sp.") of exotic, nursery-reared aquatics which he has observed as established in the waters of Florida. The possibility exists that establishment of the species was the result of the careless disposal of cultivated aquarium specimens. It is also possible that it was planted in Florida to supply local aquarium plant dealers and that it has escaped. Vegetative reproduction is extremely well developed in *H. polysperma*. Fragmented portions of the stem will readily root and produce new plants. Rataj and Horeman (1977) state " . . . even torn leaves and their fragments may take root . . . ". There is a high percentage of seed set in the Florida populations indicating that the species is probably autogamous.

Preliminary field observations in Lee County indicate that *H. polysperma* competes fairly well with *Hydrilla verticillata* (L. f.) Casp. Its ease of vegetative reproduction, its probable autogamy, and demonstrated vigor in Lee County suggest the possibility that *H. polysperma* could eventually become another nuisance aquatic weed in Florida.

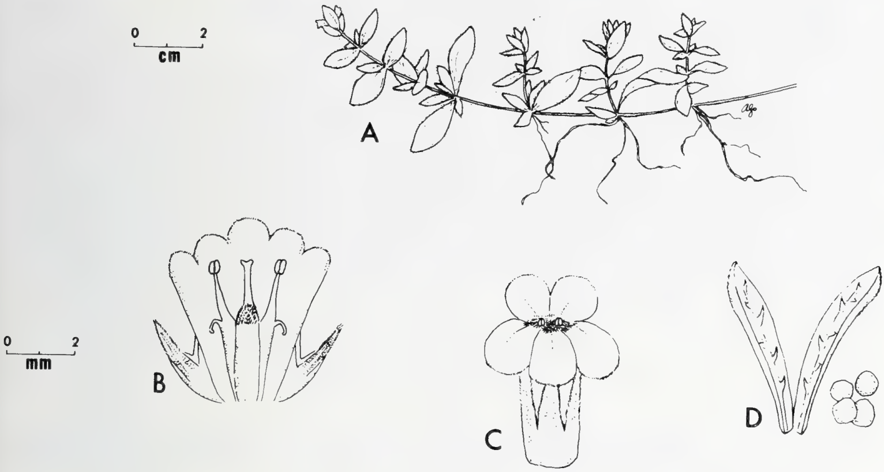

Fig. 1. *Hygrophila polysperma* (Roxb.) T. Anders. A. Habit of emergent form with inflorescences. [After *Les 170* (USF)]. B. Opened flower. C. Unopened flower. D. Opened fruit with seeds. [After *Les 201* (USF)].

HYGROPHILA POLYSPERMA (Roxb.) T. Anderson, Journ. Linn. Soc. Bot. 9:426. 1867.

Justicia polysperma Roxb., Fl. Ind. 1:120. 1820.

Hemidelphis polysperma (Roxb.) Nees in Wall., Pl. As. Rar. 3:30. 1832.

Perennial aquatic herb. Stems erect or scrambling, submergent or emergent, ± 4-angled. Leaves opposite, 2-8 cm long, lanceolate or ovate, sessile, minutely denticulate, joined at bases with ciliated flange. Flowers sessile, in axillary clusters; bracts foliaceous; calyx 5-lobed, 2-4 mm long, united near base, white-margined, pilose; corolla bluish-white (dull yellow in dried specimens), zygomorphic, 2-4 mm long, adaxial lip 2-lobed, abaxial lip 3-lobed, lobes puberulent; stamens 4, didynamous, 2 perfect, included, adnate to corolla tube, each pair of filaments connate at base by a membrane; anthers 2-celled; nectariferous disc inconspicuous; ovary superior, anteriorly pubescent, 2-locular, stigma ± 2-lobed. Fruit a capsule, 4-6 mm long, explosively dehiscent by 2 valves. Seeds minute, funiculus an antrorsely hooked retinaculum. Fig. 1.

A duplicate of the following collection which is indicated by an asterisk (*) is also on deposit at the Lee County Hyacinth Control District offices, Fort Myers.

Specimens Examined: Florida: Lee Co.: Able Canal, Lehigh Acres, T44S, R26E, S23, NW¼, December 3, 1979, *Les 170* (USF)*, January 31, 1980, *Les 193* (USF); Able Canal, Lehigh Acres, T44S, R26E, S25, NE¼, January 31, 1980, *Les 194*, (USF); February 15, 1980, *Les 201* (USF); Orange River at crossing of Buckingham Rd., T44S, R26E, S8, NE¼, February 15, 1980, *Les 199* (USF); Able Canal, Lehigh Acres, Lee Blvd. at Taylor Ct., T44S, R27E, S32, NW¼, February 21, 1980, *Les 202* (USF); Lehigh Acres, Lehigh Heights Blvd. at Bell Blvd., under bridge over Able Canal, T44S, R27E, S34, SW¼, February 21, 1980, *Les 203* (USF); Lehigh Acres, Canal crossing Lee Blvd. near Ruth St., T44S, R26E, S26, SE¼, February 22, 1980, *Les 206* (USF); Lehigh Acres, canal crossing Sunshine Blvd., T44S, R26E, S35, NE¼, February 22, 1980, *Les 207* (USF). Pasco Co.: Roadside 17 mi. N of Tampa, February 8, 1965, *Wiggins 19184* (FLAS).

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Environmental Sciences

CRYSTALLINE ROTENONE AS A SELECTIVE FISH TOXIN[1]

R. G. GILMORE, P. A. HASTINGS, G. R. KULCZYCKI,(1) AND B. L. JENNISON(2)

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ABSTRACT: *Field collections and laboratory bioassay experiments were conducted comparing various rotenone compounds and solutions with regard to their ability to stupefy and kill marine fish. Crystalline rotenone (97% pure rotenone), rotenone resin (42-45% rotenone) and premixed 5% emulsified rotenone solutions were tested as were alcohol, acetone and Aromatic 150 solvents. Marine fish and invertebrates tested were both effected by emulsified rotenone while crystalline rotenone was more specific for fish and not the marine invertebrates tested. The pure emulsifier, ATLOX 3335®, caused fatalities in* Cyprinodon variegatus.

OVER the past 60 yr ichthyologists and fisheries biologists have had much success in collecting fishes with various fish toxins. Of these toxins rotenone has received the most widespread use. Many variations of rotenone derivatives, solutions, compounds and dispersal techniques have been tried with an equal variation in results. With our current study we wanted to obtain preliminary comparative experimental data for lethal concentrations of various categories of rotenone products on the market today. The inherent difficulty of collecting fishes in open marine systems, particularly when using submersibles and "lock-out" divers, warranted the trial of various fish toxicants. Reliability without the sacrifice of potency was sought. Also of interest was the effect of these rotenone products on nontarget marine and estuarine organisms. More specifically is there a rotenone product that was only lethal to fish when dispersed in an open or semi-open aquatic system?

Rotenone in various compounds, solutions and concentrations has been used as a toxicant (i.e., central nervous system poison, Gosselin et al., 1976) for experimentation, erradication or systematic collection of various terrestrial and freshwater invertebrates (e.g., insects, archnids, crustaceans: Roarck, 1932; Leonard, 1939; Shepard, 1939; Hamilton, 1941; Fukami, 1962; Kiser et al., 1963; Meadows, 1973), birds (Cutkomp, 1943), mammals (Buckingham, 1930; Shimkin and Anderson, 1936; Fukami et al., 1967) and fishes (Leonard, 1939; Smith, 1940; Greenback, 1941; Ball, 1948b; Krumholz, 1948; Solman, 1950; Clemens and Martin, 1953; Zillox and Pfeiffer, 1956; Smith, C. L., 1973; Hocutt et al., 1973). The ability of rotenone to kill or stupefy marine fishes is of principle interest, particularly with regard to the collection of fishes from complex and otherwise inaccessible habitats (e.g., extensive cavities and caves in coral or rock reefs, mangrove marshes, rocky tidepools, deep continental shelf reef formations). Certain cryptic fishes are only collected with the use of rotenone or other fish toxicants and anesthetics. However, rotenone toxicity to members of non-target phyla is also of concern as certain habitats (e.g., scleractinian coral reefs) may possibly be directly effected by various rotenone solutions (Jaap and Wheaton, 1975). The latter reference appears to be the only work describing the effect of rotenone solutions on marine invertebrates. Although the rotenone literature is quite extensive for terrestrial and freshwater organisms particularly those in lentic habitats, it is in turn lacking for marine organisms. Excluding the Jaap and Wheaton (1975) study, marine references are not toxicological studies but are limited only to technique descriptions for collecting fish principally on living coral reef formations (e.g., Schultz, 1948; Randall, 1963; Smith, 1973). No literature was found describing detailed toxicological effects of rotenone solutions on marine organisms (i.e., LD_{50}'s). Our study is not considered to be a conclusive or detailed toxicological study, however, it presents preliminary evidence for a differential effect of various rotenone compounds on marine organisms. As permitting agencies (e.g., Florida State Department of Environmental Regulation) concern themselves with the effects of rotenone compounds on marine organisms (particularly coral reef communities) it is imperative that detailed toxicological work on marine organisms should be carried out.

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The toxic potency of rotenone solutions varies with many physiological and environmental parameters. Water turbidity, pH, alkalinity, salinity, temperature, current direction and velocity and basic water chemistry (presence of potential synergic toxic substances) may all change the effectiveness of rotenone as an ichthyocide (Leonard, 1939; Clemans and Martin, 1953; Zilliox and Pfeiffer, 1956; and Meadows, 1973). Fishes may be affected differently by rotenone depending on their susceptability or exposure in their specific microhabitats and may appear in the kill at various distinct time intervals. The rotenone solution itself may be of limited potency and may change with age and exposure to the elements. For example, the potency of rotenone as a fish toxicant decreases with its exposure to light and air (Gunther, 1943; Gosselin et al., 1976).

Initially, powdered derris root (i.e., *Derris* sp. also known as *Deguelia* of Malaya), which was available commercially in the United States, had a standardized rotenone content of 5% (Leonard, 1939; Smith, 1940; Greenback, 1941; O'Donnel, 1943; Ball, 1948a, 1948b). As emulsified rotenone became available it was preferred by some workers over the powdered derris extracts (Solman, 1950; Clemens, 1952). Currently, emulsified rotenone solutions containing 5 to 50% rotenone, powdered resins containing 42-45% rotenone, and crystalline rotenone containing 97% rotenone are commercially available. These are composed of extracts of both Malayan and East Indian *Derris* and Central and South American *Lonchocarpus* sp., familiarly known as cube'. (Gosselin et al., 1976).

We have found that several commercially available emulsified rotenone solutions used as fish toxicants have some inherent unreliability. The shelf life of some premixed emulsified rotenone solutions has, on occasion, been rather short. When launching an expensive and elaborate expedition to collect fish specimens it is disheartening to find the prime collecting material impotent. When using rotenone in conjunction with manned submersible operations at the Harbor Branch Foundation, Inc. we found it particularly advantageous to have a rotenone solution that is highly reliable.

As rotenone solutions may be ejected from our submersible over living *Oculina* sp. reefs, there has been some interest regarding the long-term effects of rotenone on deep water octocorals. There has been much recent concern by environmental regulatory agencies with the use of toxic fish-collecting agents around living coral reefs (Jaap and Wheaton, 1975). Because of this concern specimens of corals and anemones were included in the current study. Previous studies have also indicated a deleterious effect of rotenone on aquatic crustaceans (Kiser et al., 1963); therefore, palaeomoniid shrimp were included in our bioassays.

The bioassays conducted below were not intended to be extensive or conclusive, but were intended to reveal some comparative data on the relative toxicity of various rotenone solutions and solvents to both marine fishes and various selected marine invertebrates. Limited laboratory experiments were carried out comparing emulsified rotenone solutions, crystalline rotenone solutions, rotenone resin solutions and various solvents with respect to their speed in killing fish and specificity for fish rather than for various aquatic invertebrates.

EXPERIMENTAL USE OF CRYSTALLINE ROTENONE-FIELD STUDIES—In 1976 we began using a crystalline rotenone (CR) product (97% rotenone) to collect fishes along the central east coast of Florida on shallow (2-7 m depths) and deep (30-100 m depths) Atlantic reefs, lagoon mangrove marshes and in freshwater canals (for a more detailed biotope description see Gilmore, 1977). Rotenone was dispersed on deep reef formations from a manned submersible fitted with a rotenone ejection system (Fig. 1) and specimens were retrieved by a lockout diver. Field seawater salinities and temperatures varied from 0.0 to 35.0 ‰ and 15 to 30°C during these tests.

Crystalline rotenone was used in various concentrations with several common solvents: ethyl and isopropyl alcohols and acetone. Acetone was

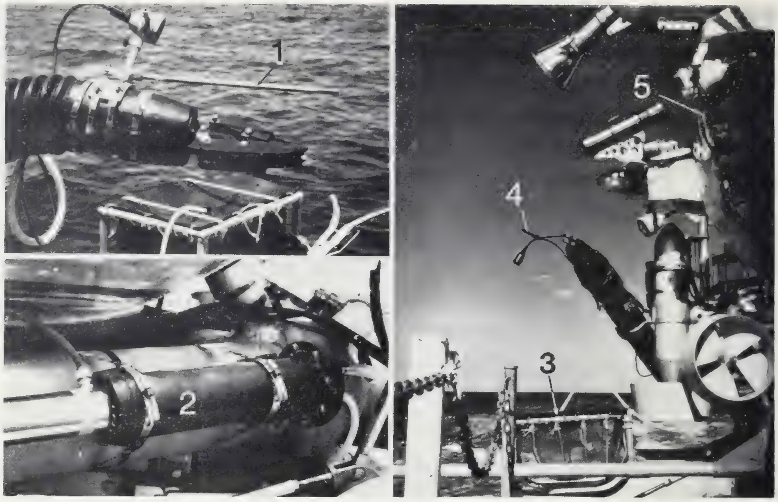

FIG. 1. Submersible ejection system used for deep reef rotenone fish collections. (1) Rotenone ejection nozzle and conveyance line mounted on manipulator arm, (2) Rotenone pump, (3) Collapsible bag used for rotenone reservoir in sub basket, (4) Rotenone nozzle, (5) Acrylic observation sphere (JOHNSON-SEA-LINK I submersible).

found to be most effective in dissolving and maintaining crystalline rotenone in solution. Several concentrations of rotenone were tried in field and laboratory experiments and it was eventually found that 0.0053 g rotenone/ml of acetone was effective in various open and semi-enclosed habitats, particularly when the solution was prepared just prior to use. Four liters of this rotenone solution, when dispersed throughout the area to be collected, produced a nearly instantaneous fish kill (within 5 to 10 min) on shallow reef formations (3-6 m depths) which under optimum conditions would eventually cover approximately 400-800 m^3 at a rotenone concentration of 0.023 to 0.049 ppm. Because we usually worked in open bodies of water it was difficult to estimate ppm CR concentrations that were effective. Closed experiments indicate that at concentrations below .025 ppm CR are ineffective. We assume that the most effective concentration is between 0.025 and 0.10 ppm, which is also a generally accepted range used by previous workers (Leonard, 1939; Krumholz, 1948). These latter authors show that lethal ppm derris concentrations using 5% rotenone derris generally range between 0.1 and 0.025 ppm rotenone. The CR/acetone solution did not cloud the water markedly when applied as do emulsified rotenone solutions, therefore, fish specimens were more readily seen and collected in tide pool situations. Recent correspondence indicates that successful collections have been made with crystalline rotenone in coastal Pakistan and Panama at concentrations varying from 0.01 to 0.04 g CR/ml acetone solutions, spread in the field to give a 0.1-0.13 ppm rotenone concentration in tide pools (Camm Swift, Los Angeles County Museum, pers. comm).

Because of the difficulty in handling acetone safely around acrylic submersible structures, another effective solvent was sought. Dimethyl sulfoxide (DMSO) was found to dissolve crystalline rotenone readily and also act as a mild synergist. Once the crystalline rotenone was dissolved in DMSO (just enough DMSO was used to dissolve the rotenone, producing a saturated solution), alcohols could be used as carriers or diluting agents. Twenty grams of CR will dissolve sufficiently in 335 ml of DMSO, which can be diluted to 3.79 l. with alcohol to produce an effective toxic solution (0.0053g CR/ml).

Very few invertebrates reacted to the crystalline rotenone/acetone mixture. Certain decapod crustaceans (e.g., *Panulirus argus*, *Mithrax forceps*, *Menippe nodifrons*) often killed with emulsified rotenone mixtures, did not show obvious stress when the CR/acetone solution was applied. Sea anemones in the areas treated kept their tentacles extended, and showed no stress externally.

BIOASSAY EXPERIMENTS—Subsequent to these field observations, a series of laboratory experiments was conducted to determine the relative toxicity or reaction rates of fishes and various invertebrates to both the emulsified rotenone solutions and the CR/acetone solution. These data are in Tables 1 and 2.

Of the 2 emulsified rotenone solutions used, only Noxfish® was available as a premixed solution. Noxfish® contains 5.0% rotenone and 10% other cube' resins for total active ingredients of 15%. The rotenone in Noxfish® is emulsified with a combination of anionic and ionic emulsifiers making up 5 to 10% of the solution (0.05 g rotenone/ml). The remainder of the Noxfish® (75-80%) consists of unknown aromatic solvents, although methylated naphthalene has been used (Joseph Haus, S.B. Penick and Co., pers. comm.). The other emulsified rotenone solution tested has been used by Dr. Gerald Allen of the Western Australian Museum, Perth, Western Australia. Dr. Allen's solution, consisting of 2.0 g dry rotenone resin, DRR, (current commercially available resins are generally 42-45% pure rotenone and ca. 50% other cube' rotenoid extracts: deguelin, toxicarol, tephrosin and sumatrol, Gosselin et al., 1976) in 74.8 ml solvent (Solvesso 150 or Aromatic 150, Exxon Chemical Co.) with 21.2 ml emulsifier (ATLOX 3335®, ICI Americas, Inc.) has also proved effective in field operations (Gerald Allen, pers. comm.). The Allen solution (0.02 g DRR/ml), like ours, can be prepared just prior to application to insure toxicity.

Four rotenone solutions without emulsifiers were tested (Table 1). (1) One gram of crystalline rotenone (CR) was dissolved in 189 ml of acetone to give a 0.0053 g CR/ml; (2) one gram of CR dissolved in 18 ml of dimethyl sulfoxide (DMSO) in 171 ml ethanol (0.0053 g CR/ml); (3) one gram dry rotenone resin (DRR) in 189 ml acetone (0.0053 g DRR/ml); (4) one gram DRR in 18 ml DMSO in 171 ml ethanol (0.0053 g DRR/ml). All of these solutions have been used for field collections with success.

TABLE 1. Bioassay 1 results after a 30 min of timed observation of both invertebrate and vertebrate specimens. D = Dead, HDO = Highly Disoriented, TC = Tentacles Contracted, CC = Column Contracted, EA = Everted Actinopharynx, NA - Normal Attitude. Parenthetical number indicates time (in minutes after application) at which death occurred.

Species	CR + Acetone*	CR + DMSO, Ethanol	DRR + A 150 ATLOX 3335® *	DRR + Acetone	DRR + DMSO, Ethanol*	Noxfish® *	Control
Bioassay 1							
ACTINIARIA							
Bartholomea annulata	NA	NA	TC,CC	NA	NA	TC	NA
Condylactis gigantea	NA	NA	TC	NA	NA	TC,CC,EA	NA
Phymanthus americana			TC,CC	NA			NA
CRUSTACEA							
Palaemonetes intermedius	NA	NA	D(25)	HDO	NA	HDO	NA
TELEOSTS							
Cyprinodon variegatus	2D(15-20) 1HDO	1D(8) 2HDO	3D(9)	1D(25) 2HDO	1D(20) 2HDO	3D(25)	NA
Lagodon rhomboides	3D(6)	3D(5)	3D(6)	3D(6)	3D(7)	3D(6-8)	NA
Gobiosoma robustum	3HDO	1D(8) 2HDO	3D(7)	NA	2D(13-25) 1HDO	1D(15) 2HDO	NA

*See test for detailed test solution formulations.

TABLE 2. Bioassay 3. Results after 30 min of timed observations. TC = Tentacles Contracted. CC = Column Contracted, NA = Normal Attitude. Preceding number indicates the number of animals, the parenthetical number indicates time (min.) at which the observed reaction first took place.

	ATLOX 3335®	Aromatic 150	Ethanol + DMSO 10 parts/1 part	Acetone	Control
ANEMONE					
Condylactis gigantea	1TC(1) CC(5)	1TC(7) CC(12)	1NA	1NA	1NA
Bartholomea annulata	3TC(1)	3CC(7)	3NA	3NA	3NA
TELEOST					
Cyprinodon variegatus	1HDO(5) 2D(30)	3NA	3NA	3NA	3NA

Methods—In our first bioassay, 7 tanks were set up simultaneously for each of the 6 test solutions and a control and filled with 10.0 liters of seawater. Three specimens of each of 3 fish species, *Cyprinodon variegatus*, *Lagodon rhomboides* and *Gobiosoma robustum* were added to each tank. Three shrimp specimens, *Palaemonetes intermedius*, were also added to each tank. Single specimens of the sea anemones (*Condylactis gigantea* and *Phymanthus crucifer* were added, along with 3 specimens of the anemone *Bartholomea annulata*, to each tank. The temperature and salinity remained constant in all tanks at 28°C and 35‰ , respectively. One ml from each of 6 test solutions (Table 1) was added to each test tank. Timed observations were made of fish and invertebrate behavior over 30 min. After the 30 min. observation period all crustaceans and fishes were preserved, while the sea anemones tested were washed with clean seawater and placed in clean aquaria for 2 mo of observation. An air stone circulated air and water in each tank during the experiment.

In the second bioassay 5 test tanks and a control with 10 1. of seawater each were used. Small colonies of the gorgonian, *Lophogorgia hebes*, octocoral, *Oculina varicosa*, solitary octocoral *Phyllangia americana* and the colonial sabellariid polychaete, *Phragmatopoma lapidosa*, were placed in each test tank. All solutions were tested as in the first bioassay using 1.0 ml of all test solutions. Behavioral observations were made over 30 min period after which all living specimens were washed with clean seawater and placed in clean aquaria for 2 mo of observation.

A third bioassay was conducted using only 1.0 ml of each solvent (acetone, ethanol, Aromatic 150) and the emulsifier (ATLOX 3335®) on 2 anemone species, *Condylactis gigantea*, 1 specimen per tank, and *Bartholomea annulata* with 3 specimens per tank. One fish species, *Cyprinodon variegatus*, was treated, with 3 specimens per tank. Again the test tanks were set up with 10.0 1. of seawater.

Results—In the first bioassay all 3 fish species tested exhibited mortalities with all solutions tested except *Gobiosoma robustum* in the CR + acetone and DRR + acetone solutions. However, we do not know whether this latter species would have recovered from the exposure of these particular solutions as these fish were preserved directly after the bioassay was made. All *Lagodon rhomboides* tested were killed in very similar time periods (5-8 min) in all solutions. *Cyprinodon variegatus* was killed most readily in the emulsified - DRR solution (1 *C. variegatus* died in the third bioassay when placed in emulsifier, ATLOX 3335® , contaminated water).

In the first bioassay the 2 CR solutions tested did not produce any abnormal behavior changes among the invertebrates tested during the 30 min exposure time period. However, in both emulsified rotenone solutions the anemones tested (i.e., *Bartholomea annulata*, *Condylactis gigantea* and *Phymanthus crucifer*) showed strong tentacle and column contractions. *Condylactis gigantea* also everted its actinopharynx in the Noxfish® test tank. Palaemoniid shrimp were killed by the emulsifed DRR solution and were highly disoriented by contact with the DRR acetone solution and Noxfish® (Table 1).

In the second bioassay the only behavioral changes observed occurred in the Noxfish test tank. The octocorals tested (*Oculina varicosa* and *Phyllangia americana*) showed a tentacle and column contraction response within 1 min. Sabellarid worms contracted into their holes, while crinoids and molluscs inadvertantly placed in this test tank were killed.

In the third bioassay the anemones reacted with tentacle and column contractions when the emulsifier, ATLOX 3335® , and the solvent, Aromatic 150, were added to their test tanks. However, the anemones did not react to ethanol and acetone solvents. The *C. variegatus* specimens in the ATLOX 3335® test tank died, but other specimens of this species did not change their behavior when any of the other solvents (i.e., Aromatic 150, ethanol, DMSO or acetone) were added to their respective test tanks.

All of the corals and anemones used in these bioassays were observed for 2 mo following the test period. All appeared to be in normal condition at the end of 2 mo including those which were adversely affected by the emulsified rotenone solutions.

DISCUSSION—The bioassay results effectively demonstrate a differential effect of the various rotenone solutions on test organisms. Crystalline rotenone solutions were lethal to most fishes tested yet did not produce noticeable behavioral changes in the invertebrates tested. The emulsified dry rotenone resin solution produced behavioral changes in all organisms tested, and proved lethal to palaemoniid shrimp and the fishes tested. Palaemoniid shrimp may be affected by a combination of rotenoids found in the DRR isolate, as the DRR-acetone solution without the emulsifier and Aromatic 150 solvent produced a "highly disoriented" (HDO) reaction in the shrimp. However, the shrimp were not affected by the DRR/dimethylsulfoxide/ethanol solution while the fishes were killed. Noxfish produced abnormal behavior and/or lethal conditions for all test organisms. Sea anemones and corals reacted only to the emulsified rotenone solutions. The purified solvent (Aromatic 150) and emulsifier (ATLOX 3335®) were tested separately on anemones and fish (Bioassay 3) and were found to produce the same anemone contraction response seen in the emulsified rotenone solutions. Our data indicate that the adverse reactions seen with the application of emulsified rotenone solutions on living corals observed by other workers (Jaap and Wheaton, 1975) may be limited to emulsified rotenone solutions (e.g., Noxfish® and Chem-Fish Collector, Appendix 1). The emulsifier, ATLOX 3335® , killed *Cyprinodon variegatus* at a concentration of 0.1 ppt (part per thousand) during 30 min of exposure.

The emulsified rotenone resin solution was more lethal to the fish tested than the other solutions (except *Lagodon rhomboides* which died readily in all solutions tested).

All solutions tested would have been effective in rendering the fishes tested collectable under field conditions, except the DRR/acetone solution which did not effect *G. robustum.* All CR and DRR solutions have been found to be effective in field operations when prepared just prior to use. The current series of laboratory examinations has demonstrated the effectiveness of various rotenone solutions in collecting the specific marine fishes tested, and the apparent specificity of crystalline rotenone for teleosts, but not for the various marine invertebrates tested. Emulsified rotenone mixtures affected the invertebrates tested possibly due to the toxicity of the emulsifier. Emulsified rotenone solutions are therefore more toxic to most organisms in the aquatic community treated with these solutions, when compared to crystalline rotenone solutions.

We would recommend certain precautions in using crystalline rotenone powder in the field. Prior to mixing with solvents and emulsifiers the powder is fine and light and is therefore easily blown by wind. Because it is 97% pure rotenone, every precaution should be taken to avoid internal absorption, inhalation and contact with open wounds, etc. Dimethyl sulfoxide and acetone solvents should also be handled with care as should synergists and emulsifiers.

Acknowledgments—We thank Carter R. Gilbert of the Florida State Museum for information regarding the purchase of crystalline rotenone and help in subsequent successful field collections. H. Adair Fehlmann of the Smithsonian Sorting Center furnished samples of rotenone resin, emulsifiers and solvents tested. Gerald R. Allen, Western Australian Museum provided information on his rotenone formulations and reviewed the manuscript. Robert H. Gore, Smithsonian Institution, Robert S. Jones, and Tsen C. Wang, Harbor Branch Foundation, Inc. reviewed the final manuscript. Mr. John Reed furnished the octocoral specimens tested and Robert S. Jones, Frank G. Stanton, John K. Reed, Wayne C. Magley, Michael R. Clark, Douglas A. Dean and Timothy L. Lewis have aided in comprehensive field collections comparing the activity of various rotenone solutions. This constitutes Harbor Branch Foundation, Inc., Contribution Number 200.

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APPENDIX 1

"Chem-Fish Collector® " manufactured by Blue Spruce Co. (50 Division Ave., Millington, N.J. 07946) contains 71.3% active ingredients, of which 7.5% is rotenone, 15% other cube' extractives, 5% synergist-piperonyl butoxide, and 43.8% miscellaneous compounds. Piperonyl butoxide is commonly used in insecticides. An aromatic solvent which is similar to acetone in its properties is used. A heavy aromatic solvent, Napha HAN, is also commonly used (Dave Butterworth, Blue Spruce Co., pers. comm.). Emulsifiers or wetting agents may vary but both the Exxon (product normally classified by code numbers) and the I.C.I. Americas Inc. product ATLOX 3335® have been in "Chem-Fish Collector® ." ATLOX 3335® is a proprietary blend of nonionic and ionic surfactants. Tenneco 500-100 (xylene type) is used as the solvent in ATLOX 3335® (D.D. Triller, ICI Americas, Inc., pers. comm.).

COMPARISON OF BENTHIC OXYGEN DEMAND MEASUREMENT TECHNIQUES

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Abstract: *Several common methods to measure benthic oxygen demand were compared using measured and literature data. An in situ respirometer technique, a laboratory core-uptake technique and a laboratory flow-through system technique were compared on sand and organic sediment in Lake Washington, Florida. In situ uptake rates were significantly higher than core-uptake rates, and this difference was greater for highly organic sediment than sand sediment. Measured and literature uptake values for in situ respirometer and core-uptake techniques with organic sediment were compared and resulted in a relationship ($r = .99$; $P < .01$) of the form: in situ uptake (g O_2/m^2-hr) = .036 + 1.16 core uptake (g O_2/m^2-hr). In many cases both core-uptake and in situ respirometer techniques under estimate oxygen consumption, due to difficulties in obtaining correct water velocities over the sediment surface. In the flow-through system studies, sediment oxygen uptake varied considerably with flow rate and a significant logarithmic relationship ($P < .01$) was obtained with Lake Apopka, Florida organic sediment. Measurement techniques that simulate field flows are the most accurate, such as the flow-through system or the in situ tunnel respirometer technique.*

The principal oxygen sinks in aquatic systems are microbial and macrophyte metabolism in the water column and biological and chemical uptake by bottom sediments. Sediment oxygen uptake has received relatively little attention compared to oxygen demand in the water column, but sediment demand can represent a significant percentage of the total oxygen uptake in some aquatic systems. In some rivers and streams, sediment can act as a stationary oxygen sink and greatly affect the "oxygen sag" characteristics of the waterway. Hanes and Irvine (1968) indicated that oxygen uptake by sediments in certain rivers may account for as much as 50% of the total oxygen depletion from the water column.

Sediment uptake rates obtained from a variety of in situ and laboratory measurement techniques range over 3 orders of magnitude (Table 1). The rates range from 0.001 g $0_2/m^2$-hr for deep sea sediments (Smith and Teal, 1973) to 1.07 g O_2/m^2-hr for coral reef communities (Odum and Odum, 1955). The lack of an accepted or approved method for measuring benthic oxygen demand, however, may contribute to inaccuracies in the reported literature because different methods used to measure benthic oxygen demand may not be comparable. Common methods of measuring benthic oxygen demand have seldom been employed simultaneously in the same aquatic system for comparative purposes (Bradley and James, 1968; James, 1974; Edberg and Hofsten, 1973). In view of this, I wanted to: (1) statistically correlate several techniques using measured and literature data, and (2) discuss the feasibility of each method.

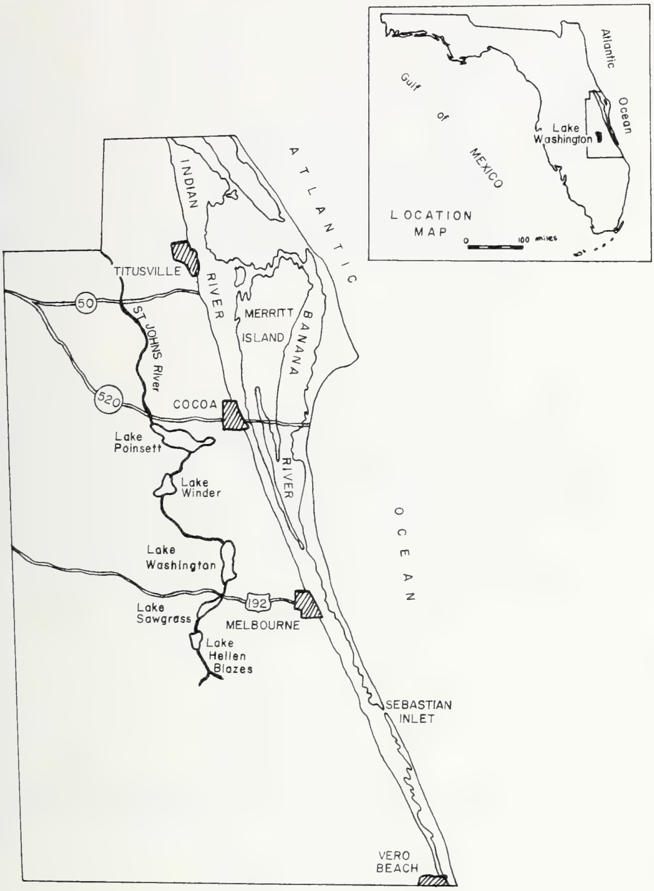

Fig. 1. Location of Lake Washington.

Sampling—Benthic oxygen demand measurements were made in August 1978 at sand (1.5% V.S.) and organic (20.5% V.S.) stations in Lake Washington, Florida. Lake Washington is the third uppermost of the naturally connected lakes of the northward-flowing St. Johns River and lies approximately 411 river Km south of Jacksonville, Florida (Fig. 1). An in situ respirometer technique, a laboratory core-uptake technique and a laboratory flow-through system technique were tested.

Core-uptake method—Several sand and organic sediment cores were taken at each station, placed in a styrofoam container, and transferred to a portable laboratory. Divers obtained the sediment cores (10 to 20 cm in depth) with 50.8 cm long plexiglas tubes (11.40 cm^2 openings). Care was taken to keep the sediment water interface in its natural state.

TABLE 1. Comparison of sediment oxygen uptake rates from several aquatic systems.

Systems	Uptake Rate (g 0_2/m^2-hr)	Method	Reference
Marine:			
Potomac Estuary	Avg - 0.10, Max - 0.36	*In Situ* Respirometer	O'Connell and Weeks, 1972
San Diego Trough Sediments	Avg - 0.003	*In Situ* Respirometer	Smith, 1974
Coral Reef Community	1.07	Diurnal Oxygen Method	Odum and Odum, 1955
Deep Sea Benthic Community at 1,850 m	0.001	*In Situ* Respirometer	Smith and Teal, 1973
Marine Sublittoral Community off Sapelo Island, Georgia	0.08 - 0.13	Lab Core Method	Smith, 1973
Unstressed Marine Sublittoral Communities (Long Island Sound, Woods Hole, Pudget Sound, etc.)	0.002 - 0.107	*In Situ* and Lab Methods	Riley, 1956; Carey, 1962, 1967; Kanwisher, 1962;
Eastern Tropical Pacific (off Peru)	0.002	Lab Core Method	Pamatmat, 1971
Northeastern Pacific	0.007	Lab Core Method	Pamatmat, 1971
Streams and Springs:			
Moose Burn (English Steam)	0.92	Lab Core Method	James, 1974
	1.13	*In Situ* Respirometer	
Cunsey Beck (English Stream)	0.15	Lab Core Method	James, 1974
	0.16	*In Situ* Respirometer	
	0.22	*In Situ* Respirometer	
Eutrophic Stream Muds—			
2 cm in Depth	0.14	Lab Reaction Chamber	McDonnell and Hall, 1969
25 cm in Depth	0.26	Lab Reaction Chamber	
Silver Springs, Florida	0.079	*In Situ* Bell Jar Method	Odum, 1957
Running Waters in Sweden	0.01 - 0.06 -	*In Situ* Respirometer	Edberg and Hofsten, 1973
Rivers:			
River Anker, England	0.04 - 0.10	Lab Core Method	Bradley and James, 1968
	0.22 - 1.09	Continuous Flow Tunnel	
	0.05 - 0.24	*In Situ* Respirometer	

River Anker, England	0.22	Lab Core Method	James, 1974
River Ivel, England	0.03 - 0.10	Lab Core Method	Edwards and Rolley, 1965
River Hiz, England	0.06 - 0.16	Lab Core Method	Edwards and Rolley, 1965
River Lark, England	0.95	Lab Core Method	Edwards and Rolley, 1965
River Coine, England	0.14 - 0.80	Lab Core Method	Edwards and Rolley, 1965
Selected English Rivers	0.006 - 0.41; Avg - 0.05	Lab Core and *In Situ* Resp.	Rolley and Owens, 1967
Lakes:			
Hypolimnion of Lake Travls, Texas	0.10 - 0.69	*In Situ* Respirometer	Steiner *et al.*, 1972
Swedish Lakes	0.02 - 0.11	*In Situ* Respirometer	
Lea Marston Lake, England	0.15	*In Situ* Respirometer	James, 1974
Esthwaite Water, England	0.39	Lab Core Method	James, 1974
	0.40	*In Situ* Respirometer	
Loch Leven, England	0.13	*In Situ* Respirometer	James, 1974
Lake Erie's Central Basin	0.01	*In Situ* Respirometer	Blanton and Winklhoffer, 1972
Lake Erie's Central Basin	0.0 - 0.10	*In Situ* Respirometer	Lucas and Thomas, 1972
Lake Esrom, Denmark	0.0 - 0.002	Lab Core Method	Hargrave, 1972
Middle St. Johns Lakes, Florida			
Lake Jessup	Avg - 0.10	*In Situ* Respirometer	Belanger, 1979
Lake Harney	Avg - 0.18	*In Situ* Respirometer	
Lake Monroe	Avg - 0.14	*In Situ* Respirometer	
Lake Apopka, Florida	Avg - 0.07	Lab Core Method	Belanger, 1979
	0.0 - 0.13	Continuous Flow-Through System (At Various $[0_2]$ and Flow Rates)	
Lake Washington, Florida			
Sand Sediment	Avg - 0.26	*In Situ* Respirometer	Belanger, 1979
	Avg - 0.20	Lab Core Method	
	0.16 - 0.27	Flow-Through System	
Peat-Muck Sediment	Avg - 0.27	*In Situ* Respirometer	
	Avg - 0.18	Lab Core Method	
	0.091 - 0.29	Flow-Through System	

In the lab, the sediment levels were adjusted to a 10 cm depth by discarding sediment from the bottom of the core. The overlying water was siphoned off and 375 mL of mid-depth lake water were added to each core. This water contained sufficient oxygen (> 5 mg/L) to conduct the uptake experiments. The water was siphoned carefully into the cores to minimize sediment disturbance. Next, the styrofoam container was filled with lake water to keep the cores at field temperature (30°C ± 2). At the same time, several empty cores were filled with lake water as control cores to estimate respiration in the water column.

Every core apparatus was filled entirely with water to insure the absence of air bubbles. After a 30 min incubation period, the dissolved oxygen in the water was measured with a YSI Model 51-A dissolved oxygen meter at 5-10 min intervals. The water in the core was closed to the atmosphere with a rubber stopper to eliminate the effects of atmospheric diffusion. The probe was positioned 10 cm below the upper edge of the tube. The purpose of the waiting period was to avoid the initial rapid uptake of oxygen by easily oxidized compounds that may have been exposed during the initial coring steps and refilling procedure. Dissolved oxygen was measured at 5-10 min intervals for approximately 2 hr. The average concentration at each time interval was plotted versus time and the rate of oxygen consumption was determined from the slope of the curve. The average control core rate was subtracted from the average sediment core-uptake rate to determine the sediment oxygen uptake rate.

To quantify the rates on an areal basis, the volume of water over the sediment in the cores (0.375 L) and the surface area of the core opening ($1.14 \times 10^{-3} m^2$) were taken into consideration:

Sediment uptake rate (mg $0_2/m^2$-hr) = 0_2 uptake (mg/L-hr) x water volume x 1/sediment area

(1) = 329 x uptake rate (mg/L-hr).

IN SITU RESPIROMETER—A benthic respirometer described by Fruh and Davis, (1972) was constructed to measure in situ benthic oxygen demand (see Fig. 2). Dissolved oxygen was measured inside the uptake chamber with the YSI membrane electrode. A stirring apparatus attached to the electrode provided slight circulation within the chamber and aided in obtaining stable readings. The oxygen electrode was fixed in position, and the respirometer was submerged and inverted to allow air to escape, before placing it on the bottom. Once in place, the apparatus was allowed to sit undisturbed for 20 min before any readings were taken to allow settling to occur to eliminate the effects of bottom disturbance. Dissolved oxygen measurements were made at 5-10 min intervals for 80 to 100 min. To quantify the rates on an areal basis, the sediment area covered by the respirometer (0.26 m^2), the volume of water over the sediment (110.8 L), and the water column respiration were taken into account as follows:

Benthic 0_2 demand (mg 0_2 m^2-hr) = [0_2 uptake (mg/L-hr) - water respiration (mg/L-hr)] (water volume) x 1/respirometer area

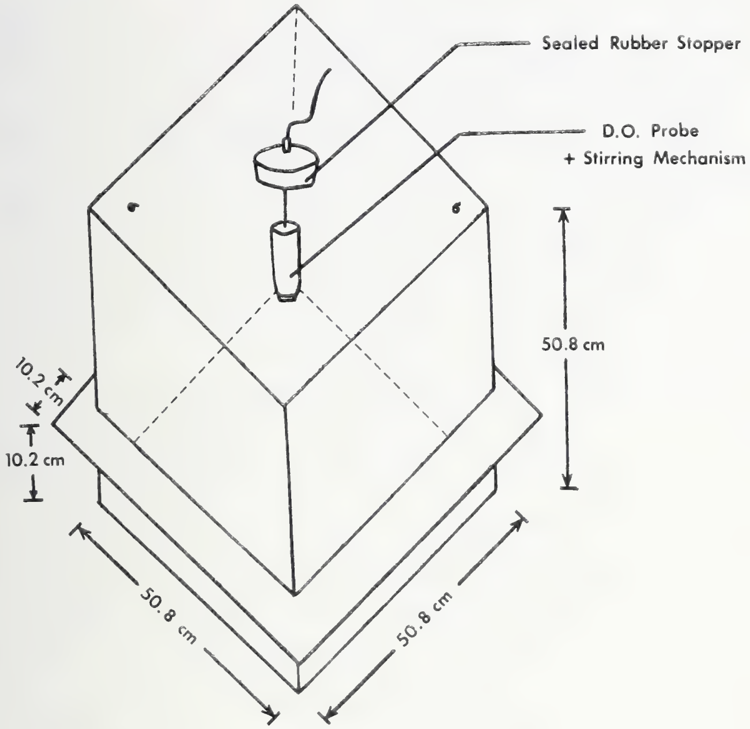

FIG. 2. In situ respirometer.

(2) $$= 426\,[O_2 \text{ uptake (mg/L-hr)} - \text{water respiration (mg/L-hr)}]$$

FLOW-THROUGH SYSTEM—The respirometer and core methods to measure benthic oxygen demand represent batch systems. The decrease in oxygen concentration in the overlying water was measured, and the results were used in calculating the oxygen uptake rates of the sediments. The following problems, however, are involved in using batch systems to measure benthic oxygen demand, and these problems may affect the results.

1. Batch systems do not approximate natural conditions because of the lack of water flow.
2. The length of each experimental run is limited to the length of time required to deplete the initial dissolved oxygen concentration in the overlying water.
3. Batch systems do not give the sediments sufficient time to acclimate

to experimental oxygen levels under consideration since the oxygen concentration of the overlying water continually decreases.

For these reasons a continuous (flow-through) system was constructed (Fig. 3) and used to measure sediment oxygen uptake rates for comparison with batch uptake rates. This flow-through system (1) better approximates natural flow conditions, an important factor in sediment oxygen uptake, and (2) permits the calculation of oxygen uptake rates along with uptake or release of other elements of interest under steady state conditions.

The flow-through apparatus consisted of 4 airtight chambers placed in series and connected by 0.95 cm inside-dia rubber hose and CPVC pipe, with appropriate fittings. Three of the chambers were constructed from Army surplus ammunition boxes which were painted on the inside with epoxy paint. One chamber was built using plexiglas so that turbidity of the water at different flow rates could be observed.

The total volume of the 4 chambers was 99.6 L, and the bottom surface area was 0.34 m^2. A submersible aquarium pump was placed in a closed plastic garbage bucket (water reservoir) and connected to the first tank with a rubber hose. Influent flow rates were varied by adjusting the position of pinch valves on the recycle line that was connected to the influent flow line (Fig. 3). A 1.27 cm inside diameter rubber return flow line entered the water reservoir so that the set-up was essentially a closed system. An air stone attached to plastic tubing was placed in the water reservoir so that the oxygen content of the influent water could be varied by bubbling in nitrogen or air. Sediment oxygen uptake studies using the flow-through system with Lake Apopka, Florida sediment generally indicated that benthic oxygen demand was independent of overlying dissolved oxygen at concentrations above approximately 2.5 mg/L, but below that level uptake rates were dependent on oxygen and decreased rapidly (Belanger, 1979). This relationship is shown in Fig. 4.

Observation of fluorescein dye in the clear plexiglas chamber at various flow rates indicated that mixing in the chambers was complete and no short circuiting between influent and effluent points occurred. Fluorescein dye was also used to simulate the range of water velocities (.05 - 1.0 ft/sec) obtained from measurements in Lake Washington and the upper St. Johns River, Florida and these velocities were then correlated to flow rates (L/hr) from the lab system. It was felt this range would encompass most in situ flow rates over the sediment-water interface. Water sample collection points were placed on the influent and return flow lines. Dissolved oxygen concentrations were determined in duplicate by Winkler titrations. Flocculent organic sediment was collected with a Ponar dredge, placed in sealed plastic buckets, and transported to the laboratory. Sand sediment was collected with box corers and carefully transferred to the flow-through chamber to keep the sediment-water interface intact. Sand and organic sediments were put in the flow-through chambers to a depth of 12.7 cm and covered with Lake Washington water that has been filtered through glass wool. Both sedi-

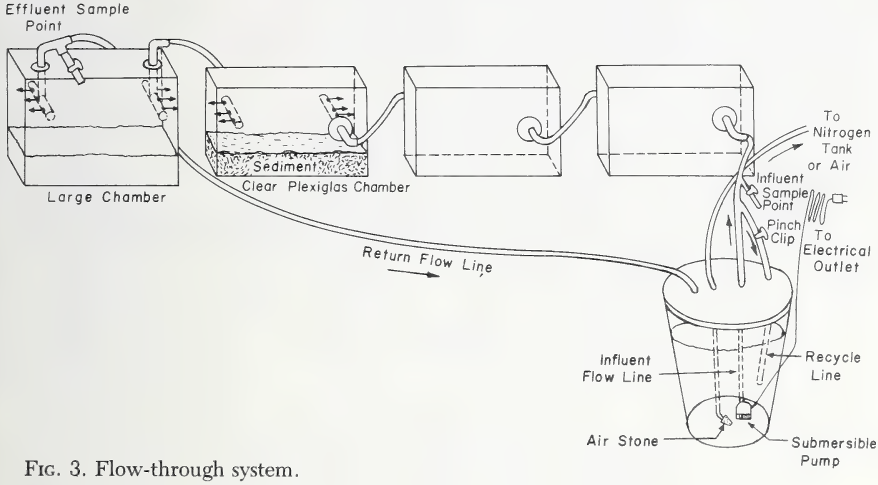

FIG. 3. Flow-through system.

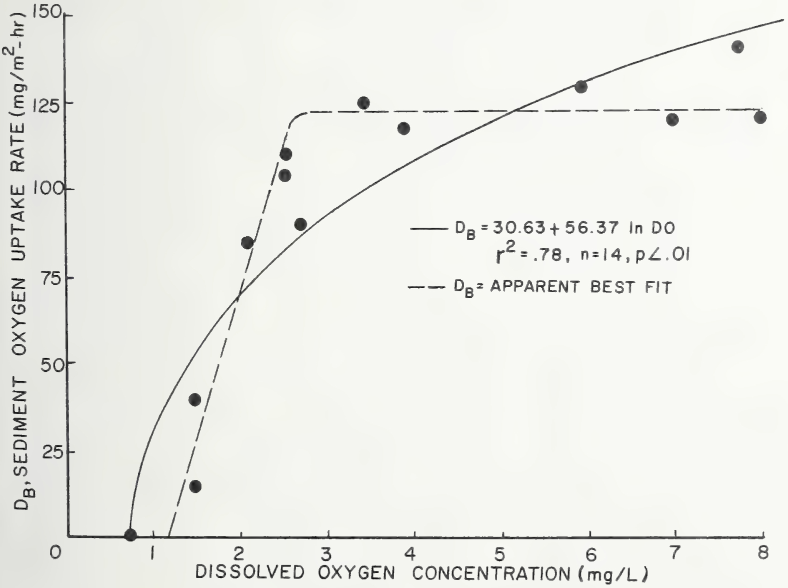

FIG. 4. Sediment oxygen uptake rate as function of overlying dissolved oxygen concentration for Lake Apopka station 2 sediment with flow rates varying from 138 to 240 L/hr.

ment types were allowed to equilibrate for approximately 7 da before the pump was turned on, and the pump was run at least one day before samples were taken. During this waiting period concentration gradients should be reestablished and in situ sediment conditions would be simulated in the organic sediment.

A simple equation was developed and used to calculate sediment oxygen uptake for the flow-through system. This equation can only be employed when the detention time at the particular flow rate in use has been equalled or surpassed. Usually a flow rate was selected and allowed to equilibrate for at least a day before samples were taken. The equation used was:

$$D_B = \left[\frac{DO_I - DO_F}{D.T.} - BOD_{D.T.}\right]\frac{V}{A}. \tag{6}$$

where D_B = net oxygen uptake rate (mg/hr-m^2),
DO_I = influent dissolved oxygen concentration (mg/L),
DO_F = effluent dissolved oxygen content (mg/L),
D.T. = detention time (hours),
$BOD_{D.T.}$ = BOD of overlying water for a particular D.T. (determined from regression equation of DO vs. time for five-day BOD),
V = volume of overlying water (liters), and
A = surface area of sediment (m^2).

RESULTS AND DISCUSSION—Overlying water temperatures in each method were similar and kept at 30°C(±2°C). Core and in situ measurements were made on the same day for each sediment type so that direct comparisons could be made. Sediment for the flow-through system was collected on these days, also, but it was allowed to equilibrate for a week before measurements were made. The results from each method are in Table 2. A summary of the flow-through system uptake results is in Table 3.

Results from the comparative study indicate that in situ oxygen uptake rates are significantly higher than core uptake rates and that this difference is greater with organic sediment than with sand sediment. The higher uptake rates in flocculent organic sediments are probably related to sediment disturbance and resuspension. Core-uptake and in situ respirometer results from replicate measurements in Lake Washington indicated greater variability in uptake rates from organic than in those from sand sediments. In fact, uptake rates with sand sediment did not vary at all with these techniques (Table 2). Uptake rates in the flow-through system, however, varied considerably with flow rate but also varied to a greater extent in the organic sediment (Table 3). Highest uptake rates were obtained with organic sediment at high flow rates. Core uptake rates with sandy sediment were approximately the same as the flow-through uptake for the same sediment type at low flows (1 to 3 hr detention time). However, core uptake rates with

TABLE 2. Comparison of benthic oxygen demand measurement techniques on Lake Washington sediments.

Station	Date	Sediment Type	Method	Flow Rate (L/hr)	Oxygen Uptake Rate (mg 0_2/m^2-hr)	Average Uptake Rate (mg 0_2/m^2-hr)
1	8/4/78	Sand	Core-Uptake	—	198	198
					198	
					198	
			In Situ Respirometer	—	256	256
					256	
					256	
			Flow-Through System	25.7-210.3	162-270	
2	8/6/78	Organic	Core-Uptake	—	165	182
					198	
			In Situ Respirometer	—	277	267
			Flow-Through System	16.0-225.6	91-294	

TABLE 3. Summary of flow-through system uptake results from Lake Washington, Florida.

Station	Sediment Type	Flow Rate (L/hr)	Detention Time (hrs)	Overlying Water Dissolved Oxygen Conc. (mg/L)	Oxygen Uptake Rate (mg O_2/m^2-hr)	Average Uptake Rate (mg 0_2/m^2-hr)
1	Sand	25.7	3.00	7.6	169, 155	162
		85.7	0.90	7.4	222, 235	228
		210.3	0.36	7.4	252, 288	270
2	Organic	16.0	4.80	7.7	73, 90	81
		98.3	0.78	7.8	181, 216	198
		225.6	0.34	7.3	266,322	294

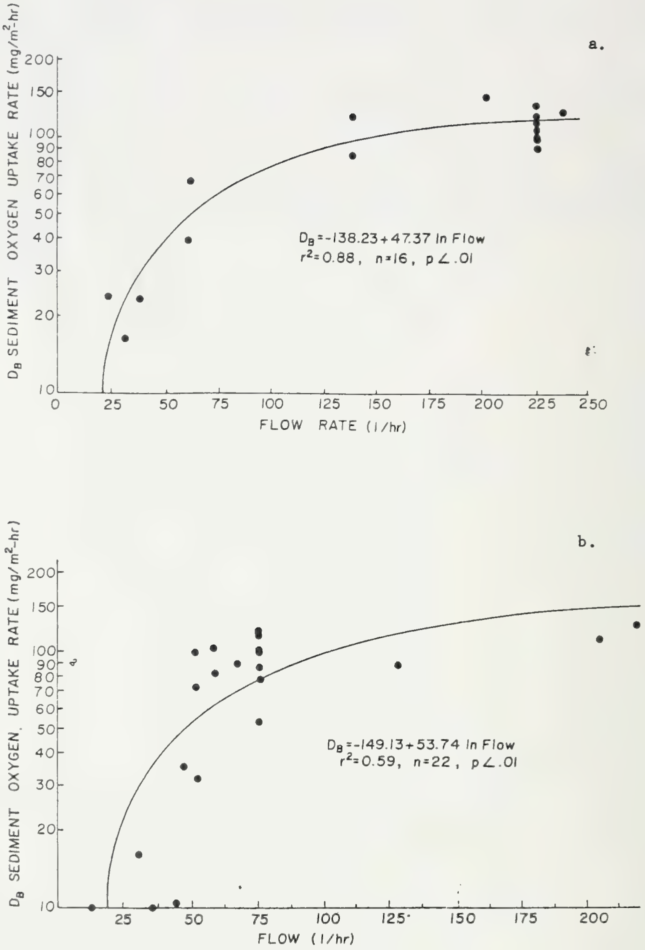

FIG. 5. Sediment oxygen uptake rate as a function of flow rate for (a) Lake Apopka north midlake and (b) south midlake sediment with overlying oxygen concentrations greater than 2.5 mg/L.

organic sediment approximated flow-through uptake at higher flows (0.75 to 1 hr detention time). In situ uptake by sand approximated flow-through uptake with a detention time of approximately 0.75 hr or less. In organic sediment, the in situ uptake approximated a flow-through uptake at a detention time of 0.50 hr or less.

In a comparison of the core-uptake, in situ respirometer, and in situ tunnel respirometer techniques in English streams, James (1974) showed that the core uptake technique and in situ respirometer method both underestimated oxygen consumption as determined by tunnel respirometers and mass balance calculations, with results from the laboratory core-uptake technique having the greatest percent deviation. Other workers have suggested that uptake rates from core methods are lower than those from in situ methods (Edberg and Hofsten, 1973; Rolley and Owens, 1967; Bradley and James, 1968). These results are consistent with findings in this study. In all cases the low values for core and in situ methods appear to be caused by a difficulty in obtaining the correct range of water velocities over the sediment surface. Results from using the laboratory flow-through system with Lake Apopka, Florida organic sediment (55 to 66% V.S.) indicated that sediment oxygen uptake rate (D_B) varied considerably with flow rate. A statistically significant ($r = .94, .75$; $p < .01$) logarithmic relationship of the form $D_B = -a + b \ln \text{Flow}$ was obtained with Lake Apopka sediment from 2 locations (Belanger, 1979). This relationship is shown in Fig. 5. In shallow streams, a large in situ tunnel respirometer as employed by James (1974) may eliminate the problem of simulating actual flows in the lab. The in situ tunnel respirometer, however, is not applicable in many aquatic systems, including lakes, deep canals, estuaries and deep rivers. In these situations a flow-through lab system such as shown in Fig. 3 may be the best method if the water velocities over the sediment can be approximated. Careful attention must be given to the flow rate in the flow through system, however, as unrealistically high rates can overestimate sediment oxygen uptake due to increased chemical oxygen demand from disturbed sediments.

TABLE 4. A comparison of sediment oxygen uptake measurement techniques (g 0_2/m^2-hr).

Sediment	Study	Core	In Situ	Flow-Through Tunnel
English River Mud	Bradley and James, 1968	0.04	0.05	0.22
		0.10	0.24	1.09
English River and Lake Mud	James, 1974	0.15	0.16	0.22
		0.92	1.13	1.59
		0.39	0.40	—
		0.22	0.35	—
		0.07	0.13	—
		0.22	—	0.42
Eutrophic English Lake Mud with Newly Deposited Algae	Edberg and Hofsten, 1973	0.05	0.08	
		0.06	0.10	
Lake Washington, Florida	Belanger, 1979			
Organic		0.18	0.27	
Sand		0.20	0.24	

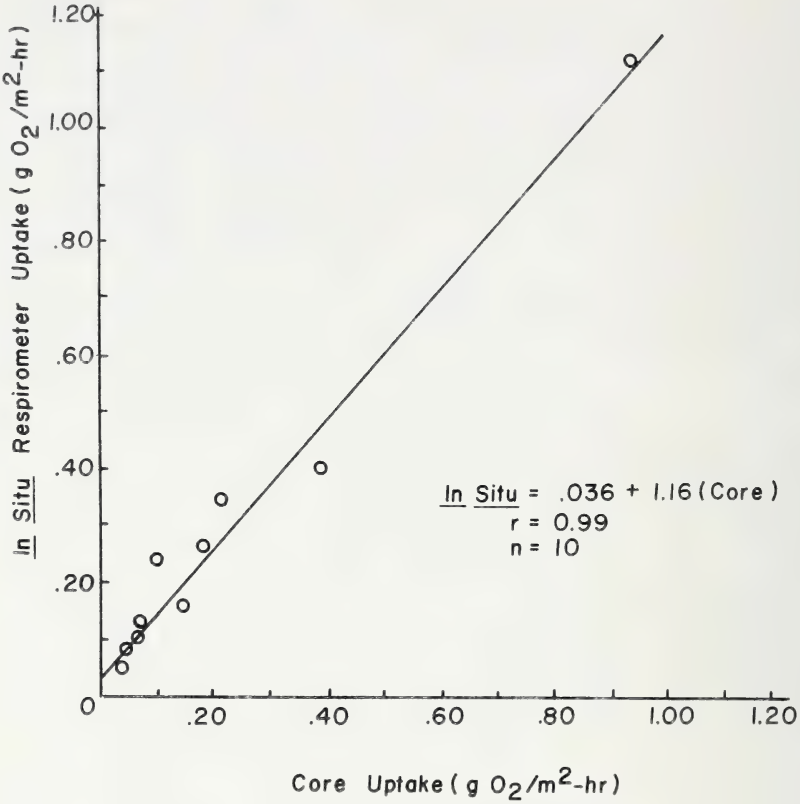

Fig. 6. Comparison of core-uptake and in situ respirometer measurement techniques.

A listing of sediment uptake rates from studies where several measurement techniques were employed is in Table 4. Uptake rates are presented primarily for organic sediment, as the lack of data for other sediment types prevented statistical comparisons. In situ respirometer and core-uptake techniques were significantly ($r = 0.99$; $P<0.05$) correlated (Fig. 6). Tunnel uptake results were compared with core-uptake rates from data collected from significantly flowing English rivers and lakes by James (1974) and a r value of 0.79 ($P<0.05$) was obtained (Fig. 7). Although a lack of data exists for the tunnel respirometer, probably due to the difficulty of constructing it, the in situ tunnel respirometer is expected to give the best results because it measures sediment oxygen uptake under in situ environmental conditions. Core-uptake results, then, significantly underestimate sediment oxygen uptake. The "best" approaches for flowing systems would be to simulate actual measured field flows in the lab or, if possible, use the tunnel respirometer technique in the field. For organic sediment systems that exhibit little flow or circulation, the in situ respirometer technique is recommended or the core

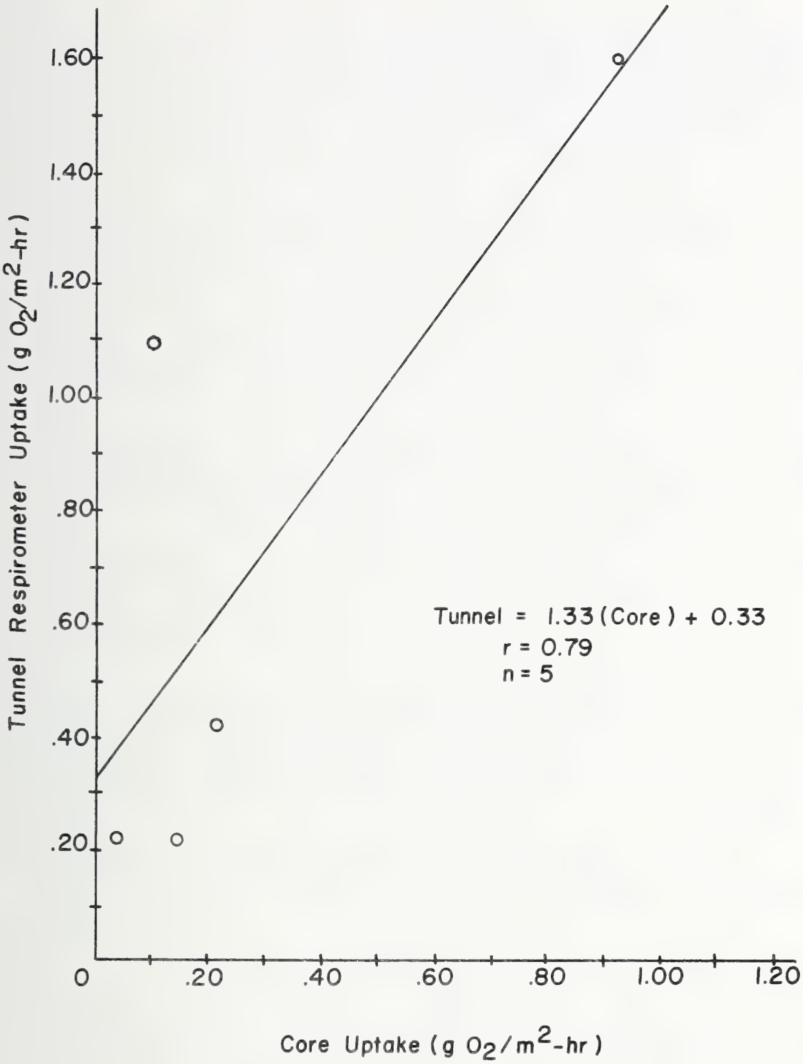

FIG. 7. Comparison of core-uptake and tunnel respirometer measurement techniques.

technique with the correction factor for conversion to in situ respirometer rates presented in Fig. 6. Although differences between the methods are generally less on sand sediments than organic sediments (Table 4), more comparative data should be collected on sand sediment to adequately establish this fact. Further data are also needed for comparisons with the tunnel respirometer, as only five data points were available in this study (Fig. 7).

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PHYSICIAN INVOLVEMENT IN HYPERTENSION CONTROL IN FLORIDA

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Abstract: *To understand physician involvement in hypertension treatment, selected specialists in Florida were queried with 2 mail questionnaires. Four-hundred forty-eight physicians, primarily cardiologists, internists and family/general practitioners responded. Over 74% treat hypertension, spending over 15% of their time doing so. Of treating physicians, over one-third do not provide hypertensive patients with educational materials; over 60% felt that a catalog of local hypertension services would not be of benefit to them. This research suggests that physician supervised treatment of hypertension by nurses and other allied health care personnel will become a reality because physicians will be forced to delegate treatment duties as more and more of the millions of currently undetected and untreated hypertensives seek treatment.*

In this study I discuss the nature and extent of physician involvement in the treatment of high blood pressure in Florida, for selected relevant areas of medical specialization.

During the early 1970's health care professionals were awakened to the significance of the hypertension problem in America. Then an estimated 25 million Americans were hypertensive. Even more significantly, only an estimated half were aware of their condition and only half of the "aware" hypertensives were estimated to be under treatment. An estimated half of those under treatment were judged to be adequately so (Stamler et al., 1974). At that time, as an initial attempt to begin coping with the hypertension epidemic, community based screening programs were initiated throughout America.

In the early 1970s hypertension was not accepted as a public health concern; it was recognized as a private medical problem (Wilber, 1975). Detection and , most importantly, treatment were most often performed by physicians in private practice. As public screening and education programs grew in extent and number within communities, several realities began to emerge. There was a need for more efficient diagnostic standardization (Gifford, 1973; Wilber, 1975). To bring meaningful numbers of previously untreated and adequately treated as well as newly detected hypertensive patients to adequate treatment would add immensely to the caseload of practicing private physicians, an estimated 5 additional wks/yr (Task Force IV, 1974).

Given this projected increase in patient load, many health care professionals called for the heavy utilization of a wide variety of health care professionals and allied health personnel in the detection, diagnosis and ongoing treatment of hypertensive patients (Wilber, 1973; Finnerty, 1975; McCombs, 1975). Some, however, noted that hypertension control was a job for physicians (Cooper, 1974). Certainly, physicians would be reluctant to delegate high blood pressure control to allied health care personnel (Task Force IV, 1974), but ultimately it would be necessary, to free physicans for other tasks for which only they were qualified.

By the mid 1970s, experimental programs had demonstrated, on a preliminary basis, that allied health care personnel could improve treatment compliance of diagnosed hypertensives, beyond rates associated with private physician care (Lee, 1974; McCombs, 1975). Moreover, guidelines for the use of nonphysician health care specialists and allied health care personnel in the campaign against hypertenison has been proposed (Lee, 1974). Use of nurses and allied health care personnel in peripheral health stations to treat hypertensives after physician diagnosis and initiation of a therapeutic regimen was advocated by the Hypertension Study Group of the Intersociety Commission on Heart Disease Resources (Hypertension Study Group, 1971).

All of the above raise important questions related to physician involvement in hypertension control. How heavily involved are they? What percentage of their patients are hypertensive? Do they perceive a need for diagnostic standardization? Would a directory of community resources be of use to them? The answers to these and other questions were sought by mail questionnaires.

METHODS—Two questionnaires, 1 short (7 questions) and 1 long (17 questions) were used. The short questionaire gathered open and closed ended data related to the physician's role in treatment and referral, caseload, hypertension caseload, time spent in treating hypertension, percent of unaware hypertensives detected and desirability of a directory of community hypertension services. The long questionnaire requested identical information, adding queries on method of patient's fee payment, patient demographic profile, education of hypertensives, patients in nursing homes, and the need for diagnostic standardization of hypertension. Each questionnaire included a cover letter explaining the nature of the survey and a postage-paid return envelope. A month after mailing, follow-up reminders were mailed to all physicians originally sent the long questionnaire. This was necessary because anonymity of respondents was guaranteed and insured by not coding return envelopes.

The survey population was defined as all practicing physicians involved in the detection and treatment of hypertension in Florida. The most current listing of Florida physicians was obtained from the Florida Medical Directory, 1974 Edition.

The survey population was delineated as follows. From the AMA roster of recognized medical specialities, 18 medical specialities were selected as being those specialities most heavily involved in the detection and/or treatment of hypertension by a cardiologist, urologist and general practitioner. The Membership Classification Code in the Florida Medical Directory assisted in the additional elimination of retired and/or nonpracticing members. After these 2 modifications the total survey population numbered approximately 4,100.

Sample sizes of 1,019 for the short survey and 411 for the long survey were determined by budget and selected ratios of the total survey population. Selection of the ratios 1:4 for the short survey and 1:10 for the long survey was based on 2 factors, the premise that the short survey would have a better return rate than the long survey made a larger sample size desirable for the short form survey. Furthermore, to enable a follow-up mailing to those nonrespondents to the long survey, it was necessary to keep the long form sample size small. Samples were randomly selected.

In each instance 6 wk were allowed for return. Nonrespondents to the long survey were recontacted after 4 wk had passed and given 4 more wks to respond.

Return rates were generally low; 32.4% for the long form, 30.9% for the short form. Family practitioners had the best return (48.2%), although of the major speciality categories, they did not spend the most average time on hypertension treatment (cardiologists—return rate 26.7%). Nor did they have the greatest mean percentage of hypertensive patients (ob/gyn—return rate 30.7%). The results of these surveys were analyzed with the Statistical Package for the Social Sciences (SPSS), on an IBM 360/65 Computer. Not all respondents answered every question.

Results—Most of the selected specialists' questioned were involved in hypertension treatment. Three-hundred twenty-nine of 442 respondents (74.4%) treated high blood pressure including over 90% of cardiologists, internists, family and general practitioners. Of 146 physicians who refer patients for treatment, the overwhelming majority (55.1%) refer to internists. Some physicians (approximately 8%) either treat or refer, depending upon the needs of the individual patient.

For all respondents the average daily patient load was 26.4; the comparable figure for physicians who treated hypertension was 26.2. The entire sample had an average of 17.0% hypertensive patients; the comparable figure for physicians who treat hypertension was 19.6%. Physicians who treated hypertension spend an average of 15.7% of their time doing so.

Of 93 responding physicians involved with hypertension treatment, 35 (27.6%) did not provide their hypertensive patients with educational materials. Fifty-seven (63.3%) of 90 treating respondents felt the need for diagnostic standardization of hypertension. Of 316 respondents treating hypertension, 193 (61.1%) felt a cummulative catalog of local organizations offering hypertension services would be of no help in their practice.

Analysis of variance, broken down by specialty of treating physicians reveals a significant difference in time spent treating hypertension (Table 1) with cardiologists spending over 20% of their time on this activity. However, a similar analysis for percent of patients with high blood pressure reveals no significant difference (Table 1).

Discussion—One need felt by the respondents to the survey was

TABLE 1. Average percent hypertensive patients and time spent treating hypertension by specialty for selected Florida physicians who treat hypertension.

Specialty	n	$\overline{X}$ Percent Time Treating Hypertension[1]	n	$\overline{X}$ Percent Hypertensive Patients[2]
Cardiology	32	20.61	33	23.92
Family Practice	29	12.14	30	14.22
General Practice	87	16.19	95	20.06
Internal Medicine	110	16.40	117	20.03
OB/GYN	8	7.88	6	26.83
Urology/Nephrology	2	7.50	3	10.00
Other	6	10.68	18	15.19
Totals	284	15.71[1]	302	19.64[2]

1. $F = 2.802$, $p < .05$.
2. $F = 1.296$, $p > .25$.

standardization of hypertension diagnosis. This has apparently been recently met with the publication of new guidelines in the Journal of the American Medical Association (Joint National Committee on Detection and Treatment of High Blood Pressure, 1977). However, the data gathered during this survey argue strongly that another, unperceived problem is emerging (if indeed it has not already) despite the fact that Florida's hypertension problem may be more widespread than that of many other states, given Florida's large aged and Black populations, the 2 groups most prone to high blood pressure.

Even if the Florida data are overestimates of national trends, the significant involvement of selected specialties in hypertension control is clear. Considering epidemiological data cited earlier, that involvement can only grow, and probably significantly. When one considers that cardiologists, internists and family/general practitioners comprise over 30% of all practicing physicians in America (Cantwell, 1976), it would appear that physicians may soon be burdened with a "hypertension" problem of their own; too many hypertensives seeking treatment, with not enough time for direct and personal physician involvement in treatment.

The problem is apparently presently being exacerbated by physicians themselves, if indeed over one-third who treat hypertension do not provide their hypertensive patients with educational materials and over 60% saw no use for a catalogue of local hypertension services. These facts suggest that Florida physicians treating hypertension believe personal care by a physician as the desired treatment modality. As mentioned previously, experimental programs have attained positive results using nurses and other allied health care professionals. Ultimately, treatment of hypertension will have to be placed in the hands of such personnel, under the supervision of physicians. The challenge today is to bring these realities, as quickly as possible to physicians, as well as to begin the systematic staffing of hypertension treatment clinics, as some foresighted public health-oriented experts called for in the early 1970s.

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SALINITY DIFFERENCES BETWEEN A HIGH AND LOW MARSH OF NORTHWESTERN FLORIDA[1]

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ABSTRACT: *An analysis of soils from a high marsh and low marsh in northwestern Florida showed that they contained large amounts of sand, and were low in cation exchange capacity and exchangeable cations. The soils examined contained high levels of soluble salts. Soils from the low marsh had higher cation exchange capacities than did the layers below.*

ALONG most of the Atlantic and Gulf coasts of North America, between the uplands and the open water, lie the tidal marsh. This is an area of economically valuable soils, although their economic values have not been thoroughly investigated and estimated. The characteristics of the soils have been documented (Coultas, 1978; 1969; Coultas and Calhoun, 1976; Coultas and Gross, 1975), but less has been done to establish a relationship between soil and predominant vegetation.

The salt marshes of North America are composed primarily of grasses, sedges and rushes which vary in productivity. A knowledge of the sodium (Na) status in proportion to other cations in the exchange complex of the soil is essential in the characterization and management of saline soils. It has been shown that tidal marshes exhibit zonation patterns, usually based on elevation (Coultas, 1970; 1969; Coultas and Gross, 1975). An inventory by Spinner (1969) grouped the Atlantic coast marshes based on the dominant vegetative species. Tidal marshes of the northwestern coast of Florida are predominately *Juncus roemerianus* and this species is the dominant member of 31% of marsh areas of Florida (Eleuterius, 1976).

There are indications that variation in nutrient regimes in salt marshes are quite significant (Chabreck, 1970). Many of the salt marsh soils in the other Gulf Coast States are either high in organic matter or clay content (U.S.D.A. and Texas Agri. Expt. Station, 1965). Comparisons between the salt content of the high marshes and low marshes will help in further establishing an understanding of the contribution of each zone to total marsh production.

The direct determination of exchangeable sodium (ES) as well as the corresponding exchangeable sodium percentage (ESP) presents certain difficulties and establishes certain relationships. A widely-used parameter has been developed by the U.S. Salinity Laboratory Staff (Richards, 1954) after examining the relationship between soluble and exchangeable sodium. The

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parameter sodium adsorption ratio (SAR), which is based on Gapon's exchange equations, is directly related to exchangeable sodium ratio and hence to exchangeable sodium percentage (ESP).

In this study I compare the salinity of soils of the high and of the low marshes of northwestern Florida. The low marsh is usually flooded on regular cyclic high tides and appear to be greatly affected by tidal inundation. The dominant vegetation in both zones is *Juncus roemerianus*; however, the vegetation density, height and diameter decrease landward.

METHODS—The investigations were conducted on soils along the coastal border of the St. Marks National Wildlife Refuge. This area is typical of the undeveloped saline wetlands of northwestern Florida.

Soil samples were taken from 2 locations (pedons) within each zone (i.e., low and high marsh). The following laboratory determinations were performed: particle size analysis, pH, cation exchange capacity (CEC), organic C, total N, salinity, exchangeable cations. Organic C was determined by the Walkley-Black method (Jackson, 1958) and N by the modified Kjeldahl method (Bremner, 1965). Conductivity determinations were made on saturated soil extracts (Jackson, 1958). Cation exchange capacities (CEC) were determined by 1N ammonium acetate (Jackson, 1958) after the soils were first leached with 50% methanol until all the chloride ions had been removed as evidenced by the silver nitrate test. The exchangeable cations were determined by atomic absorption except exchangeable Al and free Fe, which were determined colorimetrically (Chapman and Pratt, 1961; and Kilmer, 1960, respectively).

Exchangeable and soluble Na and K were extracted in an excess of 1N NH_4OAc, pH 7.0 and measured by atomic absorption. Exchangeable and soluble Ca and Mg were extracted in an excess of 1N NaOAc, pH 8.2 and determined as described by Bower (1955). Concentrations of Na, K, Ca and Mg found in the saturation extracts as described above were expressed in me/100g of oven-dry soil and subtracted from the total concentrations obtained in the NH_4OAc and NaOAc extracts to estimate the concentrations of the exchangeable cations.

RESULTS—Data in Table 1 show that in the upper regions of the pedons in the low marsh, organic carbon is high, but decreases rapidly with depth. This is also reflected in the cation exchange capacities and N content. Exchangeable K ranged between 0.10 - 0.15 me/100g in the high marsh and 0.30 - 0.61 me/100g in the low marsh. The pH values in Table 1 indicate that the soils are slightly acid, quite uniform in reaction, but slightly more acid in the high marsh.

There is also evidence of the deposition of fine (clay sized) inorganic materials in the upper regions of the low marsh making the texture loamy sand, while at slightly lower depths the materials become sandy. In the high marsh the texture is that of sand throughout the entire profile.

All soils examined have ECe > 4.0 mmho/cm and more than 15% ex-

Table 1. Some chemical and physical characteristics of the saline marsh soils.

Depth	pH (H_2O)	% Org. Matter (C)	Texture	CEC	Exchangeable Cations				% N
					Ca	Mg	Na	K	
				High Marsh					
				Pedon 1					
0-15 cm	6.0	0.8	sand	1.74	0.35	0.81	0.44	0.15	0.19
15-30 cm	6.2	0.8	sand	1.00	0.40	0.75	0.44	0.10	0.11
30-45 cm	6.7	0.4	sand	0.80	0.30	0.70	0.35	0.10	0.11
				Pedon 2					
0-15 cm	6.2	1.2	sand	2.51	0.53	1.00	0.55	0.12	0.21
15-30 cm	6.4	0.6	sand	0.90	0.50	0.90	0.50	0.10	0.14
30-45 cm	6.8	0.4	sand	0.75	0.45	0.90	0.50	0.10	0.10
				Low Marsh					
				Pedon 1					
0-15 cm	6.5	12.42	loamy sand	52.1	1.60	9.52	6.55	0.54	0.35
15-30 cm	6.8	10.00	loamy sand	39.2	1.40	9.40	6.00	0.43	0.23
30-45 cm	6.9	1.24	loamy sand	2.00	0.90	5.30	0.55	0.32	0.11
				Pedon 2					
0-15 cm	6.3	11.73	loamy sand	42.1	1.12	6.80	4.70	0.61	0.39
15-30 cm	6.6	5.04	loamy sand	20.1	1.00	6.20	4.35	0.48	0.25
30-45 cm	7.0	1.58	sand	2.8	0.85	4.10	0.62	0.30	0.10

TABLE 2. Sodium adsorption ratio (SAR). Exchangeable sodium percentage (ESP) and Conductance of the Saline Marsh Soils.

Depth	SAR	ESP	Conductance mmhos/cm	% Moisture at Saturation
		High Marsh		
		Pedon 1		
0-15 cm	0.58	25.29	15.27	29.07
15-30 cm	0.53	40.00	22.32	22.90
30-45 cm	0.50	43.75	27.22	22.81
		Pedon 2		
0-15 cm	0.63	21.91	19.68	26.60
16-30 cm	0.60	55.56	26.04	25.71
30-45 cm	0.61	66.67	34.27	23.98
		Low Marsh		
		Pedon 1		
0-15 cm	2.76	12.48	52.87	48.60
15-30 cm	2.58	15.31	52.87	48.85
30-45 cm	0.31	27.5	48.95	25.61
		Pedon 2		
0-15 cm	2.35	11.16	46.99	67.16
15-30 cm	2.27	21.39	45.12	32.93
30-45 cm	0.39	22.14	44.93	28.62

changeable Na thus classifying them as being sodic. The values for SAR and ESP (Table 2) were calculated as follows:

Na

$$(1)\quad SAR = \frac{Ca + Mg}{2}$$

$$(2)\quad ESP = (ES/CEC)\ 100$$

In the high marsh, exchangeable K ranged from 0.10 - 0.15 me/100g and was on the average, 24% of the exchangeable Na. However, in the low marsh regions, the exchangeable K ranged from 0.30 - 0.54 me/100g and was, on the average, 12% of the exchangeable Na.

The sum of metallic cations exceeded the CEC determined by ammonium saturation in all samples. This could have been due to (1) the incomplete removal of soluble salt with methanol prior to replacing the bases with ammonium ions (2) the incomplete saturation of the exchange sites with NH_4^+ or (3) the incomplete exchange of K^+ with adsorbed NH_4^+.

I believe that future research in salt marshes should focus on illucidating limiting plant growth factors to aid in proper management and should include the variation in the distribution of available nutrients.

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SCIENCE AND POLITICS: PUBLIC ATTITUDES ABOUT CREATIONISM—*Roger Handberg and William S. Maddox*, Department of Political Science, University of Central Florida, Orlando, Florida 32816

ABSTRACT: *In a sample of registered voters, we found strong support for a religious explanation of creation and for teaching those views in schools. Creationists tend to be of lower social status and have less exposure to science information and education.*

DEBATES over the science curriculum have long been a staple of American education. The more intense disputes have been in the area of what approach should be taken relative to the teaching of evolution (i.e., the Scopes monkey trial). In 4 states, laws were passed although often only erratically enforced, which banned the teaching of evolution in the public schools. In a total of 37 states, such laws were debated.

The dispute in more recent years has shifted from a concern with the teaching of evolution per se to the requirement that *Genesis* be taught as an alternative theory of creation (Wade, 1972; Nelkin, 1979). This has been termed "creationism." Creationism stated simply is that the book of *Genesis* presents a viable scientific explanation for the origin of life. That is: the origin of life is best explained in terms of a theory of divine creation in accord with an intelligent, purposeful plan. This theory is not subject to experimental falsification because certain events are postulated rather than observed. Supporters of creationism argue that the latter point is also true of evolutionary theory. Nelkin (1977: 60-76) has identified the major components of what might be termed the scientific creationist establishment. These individuals are attempting to develop a world view which treats the Bible as a scientific document. Evolution becomes a much reduced process with only limited variations allowed within the grand design ordained by God. Given their intense commitment to this world view, the creationists have been extremely active in a number of states in pressuring textbook adoption committees to require that the theory of Creation be a required part of the textual material. For example, in Texas, Cook-Freeman (1979) found the creationist controversy in textbook selection to be a long-term battle.

What is lacking in many of these discussions is any feel for what the general population feels about this particular issue. Most of the battles have been within the confines of small segments of the educational and religious establishments. Most of the assessments of public opinion have, in fact, relied upon external labels to identify potential or actual adherents. For example, Nelkin (1977: 43-46) relies in part upon church membership such as Assemblies of God, Southern Baptists, and Seventh Day Adventists. We present some evidence relative to the distribution of creationist views in the general public and some correlates of those views.

Sample and Research Design—In the summer of 1979, a pilot study was conducted of registered voters in Orange County, Florida. The small size of the sample (N = 157) limits the generalizations possible, but allows one to identify broad attitudinal groupings. The pilot study represents an attempt to test a general Science Attitudes Scale (SAS) one which had initially been developed using college students (Handberg and McCrae, 1980; Handberg and Maddox, 1980). As part of that effort, a scale dealing with creationism was included as an external validator of SAS.

The respondents in this study are demographically typical of Orange County, Florida voters who registered primarily as Democrats (60%), but are split more evenly in terms of actual party preference (Democrat—40%, Republican—43%). The sample slightly overrepresents females (57%), while the nonwhite proportion is close to the community profile (14%). The mean age is 47 yr old (this is inflated because of the sampling frame). Educationally, the average is 13 yr of formal education with the predominant occupational categories being housewife, white collar, and retired. Twenty-one percent of the sample were college graduates—only one indicated advanced graduate work. The average and median income level was in the category of $15,000 to $17,499. The respondents can be characterized generally as white middle class homeowners.

Creationist Scale—Some earlier work by Handberg and McCrae (1980) dealing with science attitudes among college students had identified certain issues as being unrelated to the domain of more generalized science attitudes. These attitudes appeared to be more religiously based. Later work by Handberg and Maddox (1980) was able to isolate 2 dimensions: attitudes toward general science and attitudes toward God and religion. The items used in the scale here are not direct linear extrapolations of the earlier questions but represent modifications (made on the basis of the previously cited research projects) which directly tap belief in the Genesis version of creation and its validity in science education. In Table 1, we report the 5 scale items along with the response distributions. These 5 items were recoded and then treated as an additive Likert-type scale.

The items reported in Table 1 were embedded in a survey instrument which included a variety of questions dealing with media, politics, presidential candidates, and science attitudes. The first 2 scale items probe directly at the issue which underlines the conflict over science curriculum. (i.e., should the schools present a view of the world significantly at variance with that of the community)? The answer given by a majority of our respondents is no (55%), an answer which conforms to the general history of American education at the primary and secondary levels. Note the similarity of the response to both items--given that the first item does not explicitly refer to science.

Table 1. Percentage distribution for creationist scale items.

Item	Agree	Disagree	Uncertain
Materials in textbooks should not conflict with religious beliefs.	55	40	5
Any science which conflicts with religious beliefs should be taught cautiously, if at all, in our schools.	55	38	6
Evolution should be taught in schools as fact.	29	61	10
Genesis should be taught as alternative view of creation.	59	24	17
The world was created by a cosmic explosion or what we might call a big bang.	12	61	27

N = 157

The third and fourth scale items refer explicitly to the controversy over creationism. Clearly, evolution as a theory of fact is not supported by many of the respondents. They wish to have an alternative view presented to the students. What is important here is that 59% want Genesis taught. Item 5 was put in the scale because (whatever its cosmological accuracy) the question presents a clearly nonreligious explanation for Genesis. Only 12% were willing to accept this "scientific" explanation. Overall, the separate items indicate that many of the respondents are unwilling to accept science if it conflicts with firmly held religious truths and are willing to have Genesis taught as an alternative to evolution in the schools.

Correlates of CS—In Table 2, we present the gammas between the Creationist Scale (CS) and selected demographic variables. The demographic variables have been grouped into 4 broad categories: personal characteristics (i.e., race and sex), Bible/church variables, science training/information variables, and more general social-political views. As was indicated above, the CS is a likert-type scale with a range from 0 to 5 with a mean of 2.6 and a median of 2.7.

Table 2. Relationships between creationist scale and theoretically relevant external variables.

	Gamma with CS
Demographics	
Income	−.27
Age	.07
Race	.41
Sex	.09
Educational Experience	
Years of Education	−.25
Level of Science Information (4 items)	−.29
Media used for science information	−.24
Exposure to high school science courses	−.12
Work-related science/technical training	−.39
College major	−.20
Religious and personal attitudes	
Church attendance	.09
Use of the Bible in Daily Life	.07
Literal Interpretation of Bible	.58
Personal control	.16
Political Attitudes	
Party identification	−.12
Ideological classification	−.01

It is clear that the Creationist attitudes do have some demographic basis or structuring. The more creationist-minded individuals tend to be low income, female, minority group respondents. Educationally, they tend to be less educated in general and with regard to exposure to science. There are consistently negative relationships between creationist views and the level of information about science, exposure to science courses in high school, and use of more detailed media (magazines or newspapers as opposed to television or radio) for obtaining information about science. Exposure to job-related science or technical training (only 15% of our sample reported such training) and whether the college major was science-oriented or not also were negatively correlated with creationist views. Along the religious dimension, the critical factor appears whether one holds the Bible literally or not. Measures of church attendance and the use of the Bible as a guide to daily life do not correlate as strongly as fundamentalist views on the Bible. There is also some indication that individuals who feel they can control their own lives feel somewhat more comfortable with creationist views. This corresponds to their religious fundamentalism and their commitment to a particular way or approach to life. Democrats were slightly more likely to be procreationist in views—a partial reflection of the class differences between the Democratic and Republican electoral coalitions. Ideologically, there appears to be no conservative or liberal position on creationism at least as expressed by our sample.

Conclusion—As can readily be seen in this sample, public support for science in its various manifestations is a tenuous proposition. Traditional and religiously based explanations for natural phenomena are still important in structuring public perceptions in the area of school science curricula and related matters. What is of interest is the fact that this sample consists of registered voters—individuals who at least at some nominal level are involved in the political system and more prone to act than their apathetic brethren. What has muted the impact of these views is the fact that most educational and curricular decisions are made essentially by small groups of educational professionals. Public participation while symbolically present has been controlled and dissipated in most instances. In Florida, though, the legislative battles are beginning over the issue and the State Board of Education (the Governor and the Cabinet) has already had to rule on this issue once in 1980. Our results indicate that public support for creationism may be more widespread than imagined by most scientists.

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BEHAVIOR PATTERNS IN THE WEST INDIAN MANATEE, WITH EMPHASIS ON FEEDING AND DIVING

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Abstract: *Behavior patterns in West Indian manatees* (Trichechus manatus) *were observed and evaluated at Blue Lagoon Lake, Miami, Florida. Herd size, location, and time of day were correlated with various activities. Manatee movements were unrelated to tidal conditions. Submergence times of the manatees varied directly with size of the animal, except for female-calf pairs who breathed synchronously, possibly to keep the animals together. Submergence times for each of 3 size classes of manatees decreased with type of activity in the following order: resting, feeding, cruising. Submerged plants were eaten more often than either natant or emergent ones, and* Hydrilla verticillata *was the most commonly consumed plant.*

The most complete study published to-date on the behavior and ecology of the West Indian manatee *(Trichechus manatus)* involved a winter population around Crystal River, Florida (Hartman, 1971, 1979). The lack of comparable behavior data from other studies was emphasized in Husar's (1977) thorough literature survey. The participants of a recent workshop on the West Indian manatee recognized that the general lack of biological data (emphasized in Hartman, 1971, 1979; Reynolds, 1977, 1979, in press A, in press B; Powell, in press) has hindered efforts to conserve this endangered species, and they urged that efforts be made to remedy this situation (Brownell Ralls and Reeves, 1978). This study augmented existing data and provided new insights into manatee behavior and natural history by documenting activities observed in a manatee population present year-round in southeastern Florida.

Study site—A group of approximately 50 manatees inhabiting Blue Lagoon Lake, Dade County, Florida, was studied. This man-made lake occupied an area of 68 ha and was located just south of Miami International Airport (Fig. 1). Blue Lagoon and its associated waterways lay on the Tamiami Canal, west of its juncture with the north fork of the Miami River. Until 1965-1966, water in this system was allowed to flow uninterrupted from the Tamiami Canal to the Miami River, and from the river to Biscayne Bay. At that time, the Central and Southern Florida Flood Control District (presently South Florida Water Management District) installed salinity intrusion barriers on the Tamiami Canal, one at the eastern and one at the western end of the lake system (Fig. 1). The group of manatees inhabiting the area at that time was apparently trapped in the lake by these structures.

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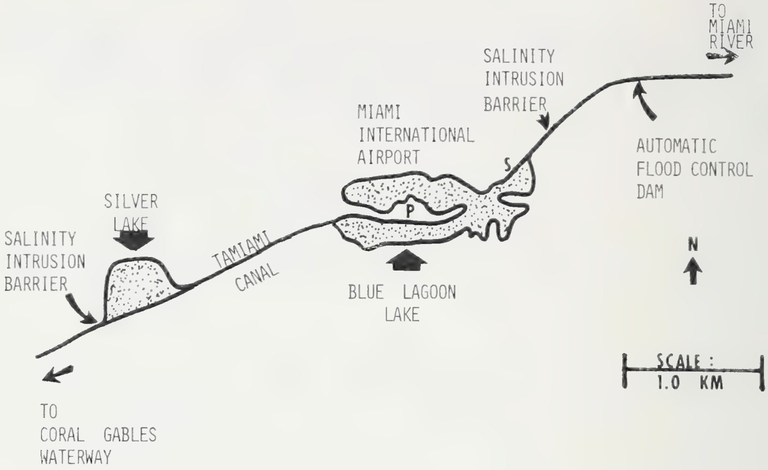

Fig. 1. Blue Lagoon and major associated waterways, showing the positions of salinity intrusion barriers, automatic flood control dam and other landmarks. (P is the peninsula in Blue Lagoon; S is the sunken barges)

The Central and Southern Florida Flood Control District later built an automatic flood control dam at the eastern end of Blue Lagoon; when this structure became operational in May 1976, the salinity instrusion barriers were removed, allowing the manatees to leave Blue Lagoon (Reynolds, 1977).

The water in Blue Lagoon was fresh, with maximum salinity reaching about 0.8 ppt during extremely high tides. The salinity was usually less than 0.1 ppt. Water temperatures in the lake varied seasonally from about 21 °C in December to over 27 °C in July (Lutz, 1976). Other physical aspects of the water in the Tamiami Canal, west of Blue Lagoon were considered by Lutz (1976).

Hydrilla verticillata, commonly called hydrilla or Florida elodea, was the most abundant submerged plant in Blue Lagoon, although *Ceratophyllum demersum*, *Eichhornia crassipes*, *Lemna* spp. and several species of algae (e.g., *Anabaena*, *Mougeotia*, and *Spirogyra)* were also present. *H. verticillata*, exotic in Florida, virtually replaced all native vegetation in the lake. *C. demersum* was fairly common in late summer, but its distribution was sparse and patchy within the masses of *H. verticillata*. All other submerged plants were uncommon year-round. *Panicum hemitomon* and *Phragmites communis* were abundant on the shores of the lake.

Survey methods—Surveys of manatees at Blue Lagoon were conducted from the shoreline, from a 4.6 m fiberglass canoe and by snorkeling when water clarity permitted. Over 400 hr were spent searching for animals from April 1975 to February 1977. Surveys were conducted between 0500 and

2400 hr (EDT) with most occurring between 0700 and 1900 hr (Reynolds, in press B). Details of survey methods and data collection and analysis have been described elsewhere (Reynolds, 1977, in press B), but they emphasized identification of individual animals, evaluation of daily activities, and appraisal of social interactions.

Data concerning manatee activity patterns were analyzed using the following statistical tests: 1) chi-square to evaluate whether tides downstream of the structures affected manatee movements; and 2) Spearman's rank correlation procedure to test different variables' effect on manatee movements (Zar, 1974).

Manatees' feeding was evaluated in 2 ways. Feeding sessions were defined as any number of animals feeding for any length of time; feeding times were defined in terms of animal hours (i.e., as the duration of each feeding session multiplied by the number of animals involved).

Differences in mean submergence time (MST) for different sized individuals enaged in the same activity and for a given size class of manatees doing different activities were tested using a nonparametric Kruskal-Wallis test (where $k > 2$) or a Mann-Whitney U-test (where $k = 2$) (Zar, 1974). In these tests the following size classes were defined (as suggested by Odell, (1977): calves were animals < 1.8 m long; juveniles were 1.8-2.6 m long; adults were > 2.6 m long.

SPATIAL AND TEMPORAL ACTIVITY PATTERNS—Manatees appeared downstream from flood control structures equally often on outgoing and incoming tides (11 and 9 times, respectively; chi-square: $0.995 < p < 0.999$). Incoming and outgoing tides were sampled equally (66 incoming and 50 outgoing; chi square: $0.25 < p < 0.50$).

Manatees in Blue Lagoon displayed some spatial and temporal activity patterns which involved 1) restricted areas of the lake, 2) certain hours of the day, and 3) rather consistent herd sizes (Spearman's rank correlation tests; $\alpha = 0.05$; Table 1; Table 2). For example as indicated in Tables 1 and 2, number of animals and their activity were correlated at 3 discrete locations in Blue Lagoon: 1) upstream of flood control structures, 2) near some sunken barges, and 3) south of the peninsula (Fig. 1). Time of day and location in the lake were correlated when manatee activities were either cruising, barrier climbing, body-surfing, or follow-the-leader (see Table 2 for definition of terms). When manatee activities included resting, cruising, body-surfing, barrier climbing and alternately resting and nuzzling, number of animals was correlated with location. Finally, manatee activity and location were correlated when herd size was either 6 or 7.

The relatively quiescent activities (resting, feeding, nuzzling, and alternately resting and nuzzling) occurred with equal frequency throughout the day. Resting and alternately resting and nuzzling usually involved small herds or single animals located upstream of flood control structures. Feeding and nuzzling, conversely, involved no predictable herd sizes or locations. Activities requiring relatively great exertion (cruising, body-surfing, barrier

TABLE 1. Results of Spearman's rank correlation test to determine whether correlations exist between variable pairs, showing relationship between number of manatees, season of year, location, time of day, and activity. Significant correlations were demonstrated where $P < 0.05$.

Variable Pairs	n	r_s	P
Number of animals and season	307	−0.0511	0.186
Number of animals and time of day	307	−0.0669	0.121
Number of animals and location	307	0.1959	0.001
Activity and season	294	0.0252	0.333
Activity and time of day	294	−0.1785	0.001
Activity and location	294	−0.0096	0.435
Number of animals and activity	294	0.2072	0.001

climbing, and follow-the-leader) were essentially restricted to the morning and late afternoon-early evening hours.

FOOD AND FEEDING HABITS—Manatees in Blue Lagoon fed on submerged, floating, and emergent vegetation. *Hydrilla verticillata* was eaten most commonly, involving nearly 86% of the total feeding sessions and over 92% of the total feeding time (Table 3). The relative amount of time spent feeding on each plant species and on combinations of plant species was calculated (Table 3).

Submerged plants were eaten most frequently (about 77% of the time) and included *H. verticillata*, *Ceratophyllum demersum* and an algal complex composed mainly of the unbranched filamentous green algae, *Mougeotia* and *Spirogyra*. This algal complex was found attached to the rocks, pilings, and dams.

Manatees in Blue Lagoon fed on submerged plants in several ways, ranging from intermittent feeding on sparse vegetation or algae to prolonged feeding in one location. The latter feeding method resulted in obvious holes in the masses of vegetation. Individual feeding sessions ranged in duration from several seconds to over 45 min. One adult female fed for 159 min over a 240 min period, with short, intermittent rests. Calves generally fed intermittently.

Floating plants were the next commonly consumed plant group at Blue Lagoon, eaten during about 14% of the manatee's feeding time. These plants were either eaten at the surface or they were pulled underwater and consumed there. Among the floating plants eaten were pieces of *H. verticillata*, large stalks of mown or uprooted *Phragmites communis* (held in place with the pectoral flippers) and a floating algal complex. The latter was composed mainly of filamentous blue-green algae, especially *Anabaena*, green algae such as *Spirogyra* and *Rhizoclinium*, and the yellow-green alga, *Vaucheria*.

Consumption of emergent plants occurred about 9% of the time during which the manatees hauled themselves partially out of the water. Most commonly, they simply extended their heads and shoulders onto the bank during this activity. In one instance, however, a large adult hauled over half of its body out of the water to feed on *Panicum hemitomon*, although the plant grew down to the water, making such hauling-out unnecessary. The only plants that manatees consumed onshore in this fashion were *P. hemitomon* and *P. communis*.

SUBMERGENCE TIMES—The maximum submergence time for any manatee observed in Blue Lagoon was 24 min for a resting adult. Comparisons of mean submergence times (MST) indicated 2 general trends (Kruskal-Wallis and Mann-Whitney tests; $\alpha = 0.05$; Table 4). First, for each size class of manatees, MST generally increased with activity in the following order: cruising, feeding, resting. Further, MST was generally not equal for different sized individuals engaged in the same activity; exceptions to this generality involved female manatees accompanied by small calves.

SPATIAL AND TEMPORAL ACTIVITY PATTERNS—The question of whether manatees were nocturnal, crepuscular, or diurnal has been debated. Several observers (Barrett, 1935; Allsopp, 1961; Bertram and Bertram, 1964) stated that the species was crepuscular or nocturnal. Others (Parker, 1922; Hartman, 1971) felt that manatees were active throughout the day and night, but Hartman (1971, 1979) indicated that animals' daily activity patterns were essentially arhythmic. Manatees at Blue Lagoon, in contrast, demonstrated certain behavior patterns. J. Bengtson (pers. comm.) also observed day and night activities as well as some apparent patterns of movement in St. John's River manatees. Jonklass (1961) studied another member of the Order Sirenia, the dugong *(Dugong dugon)*, and found that while captives were arhythmic, free-ranging animals in populated areas were more active at night, presumably to avoid human hunters. The observed absence of body-surfing, cruising, and follow-the-leader at Blue Lagoon during the mid-day hours was possibly for avoidance of boat traffic which was heaviest there at that time of day. Tidal flow did not appear to affect manatee movements. Anderson and Birtles (1978) found that dugongs fed during both night and day.

FOOD AND FEEDING—Allsopp's (1969) studies of manatees in Guyana indicated the same order of preference by the animals for different plant types as found in this study: submerged, floating, and emergent. Hartman (1971) noted that manatees in Crystal River ate only submerged plants, with the exception of 2 instances in which animals pulled floating water hyacinths *(Eichhornia crassipes)* underwater and consumed them there.

Manatees in the headwaters of the Crystal River concentrated their feeding on 4 species of submerged plants: *Myriophyllum spicatum*, *C. demersum*, *H. verticillata* and *Vallisneria neotropicalis* (Hartman, 1971, 1979). In adjacent brackish waters, another submerged species, *Ruppia maritima*, formed the bulk of the animals' diet (Hartman, 1971, 1979).

TABLE 2. Significant correlation demonstrated by Spearman's tests to determine whether manatees showed regular patterns of movements. $\alpha = 0.05$ for all tests. Histogram of survey hours presented in Reynolds (in press A).

I	II	III
Spearman's Test to Determine Whether:	Significant Correlations Found	Dominant Features and % of Total Observed Occurrences for Corresponding Letter in Column II
1) Number of animals was correlated with activity when location was:		
	a) Immediately upstream of flood dams (P = 0.001; n = 126)	a) Animals rested (77%); single animals (48%)
	b) Near sunken barges (P = 0.019; n = 11)	b) Variable activities, resting dominant (36%); few single animals (9%)
	c) South of peninsula (no P value because n < 6)	c) Cruising herds of 3 animals (100%)
2) Time of day was correlated with location when manatee activity was:		
	a) Cruising (P = 0.016; n = 22)	a) Located upstream of flood dams (46%); always seen between 0800 and 1000 (68%; n = 15) and 1500-1800 (32%; n = 7)
	b) Barrier climbing (P = 0.001; n = 13)	b) Located at salinity barriers (100%); seen between 0700 and 0900 (69%; n = 9)
	c) Body-surfing (P = 0.001; n = 21)	c) Located downstream of flood control structures (100%) observed from 0700-1200 (71%; n = 15) and 1630-1800 (29%; n = 6)
	d) Follow-the-leader (no P because n < 6)	d) Most often near barges (40%); seen in the morning (80%; n = 4)

3) Number of animals was correlated with location when manatee activity was:	a) Resting ($P = 0.001$; $n = 130$)	a) Seen near flood control structures (74%); involved single animals (36%) and herds of 2-3 animals (45%)
	b) Cruising ($P = 0.028$; $n = 22$)	b) Herds of 1-3 animals (100%); upstream of flood control structures (46%)
	c) Body-surfing ($P = 0.001$; $n = 21$)	c) Herds larger than 3 animals (91%); downstream of flood control structures by definition
	d) Barrier climbing ($P = 0.001$; $n = 13$)	d) Single animals (46%) but herds larger than 3 animals (39%); at salinity barriers by definition
	e) Alternately resting and nuzzling ($P = 0.010$; $n = 22$)	e) Herds larger than 3 animals (32%); upstream of flood control structure (55%)
4) Activity and location were correlated when herd size was:	a) Six ($P = 0.002$; $n = 19$)	a) Near flood control structures (84%); involved Resting (95%)
	b) Seven (no P value because $n < 6$)	b) Upstream of flood control structures and alternately resting and nuzzling (67%)

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[a] Cruising = prolonged swimming.
[b] Barrier climbing = alternately resting and trying to climb over a salinity intrusion barrier.
[c] Body-surfing = riding currents generated downstream of flood control structures.

TABLE 3. Relative amounts of time spent feeding on different plants by manatees in Blue Lagoon.

	Number of Animal Hours	Percent of Total Hours	Number of Feeding Sessions	Percent of Total Feeding Sessions
Hydrilla verticillata only	21.31	65.93	37	67.27
H. verticillata plus *Ceratophyllum demersum*	3.00	9.28	6	10.91
H. verticillata, floating algae, plus *Phragmites communis*	4.40	13.62	1	1.82
H. verticillata plus *Panicum hemitomon*	0.80	2.48	2	3.64
H. verticillata plus floating algae	0.33	1.03	1	1.82
Phragmites communis only	2.17	6.71	4	7.27
Panicum hemitomon only	0.25	0.77	1	1.82
Attached algae only	0.06	0.19	3	5.46
Totals	32.32	100.0	55	100.0

Where submerged plants cannot grow due to water turbidity, manatees apparently relied on floating plants such as *E. crassipes*, *Alternathera philoxeroides* and *Salvinia rotundiflora* for food (Moore, 1951b; Sguros, 1966).

Observations of Blue Lagoon manatees hauling-out to feed supported earlier reports (Bangs, 1895; Barrett, 1935; Moore, 1951b; Bertram and Bertram, 1968). Where aquatic vegetation was scarce, manatees possibly needed to haul out to obtain adequate amounts of food for survival, but aquatic vegetation was abundant in Blue Lagoon so this reason does not appear to explain this behavior in the lake.

The prevalence with which Blue Lagoon manatees ate *H. verticillata* should be qualified. This plant was the most common aquatic species, and consumption of it may have reflected convenience rather than choice. Of greater significance in terms of choice may be the percentage of time spent feeding on emergent species which were difficult for the animals to reach.

Manatees in Blue Lagoon ate the attached green algal complex by itself, but only consumed the floating algal complex with other plants (Table 3). J. Prince (pers. comm.) suggested that due to the abundance in the floating complex of blue-green algae, some of which were toxic to other species, this complex might not be deliberately sought as food.

Manatees in Blue Lagoon were never observed eating fish or invertebrates, but the animals probably ingested numerous aquatic invertebrates incidentally with vegetation as suggested by Hartman (1971, 1979). Powell (1978) reported that manatees in Jamaica ate fish caught in nets.

TABLE 4. Average submergence times (in seconds) for manatees of each size class engaged in different activities. n_1 represents the total number of occasions for which submergence times were recorded for an animal of a given size class and a given activity. n_2 is the total number of submergence intervals recorded for each size class and each activity. $\overline{X}$ and r^2 are the mean submergence time and variance for each n_2.

Activity	Size Class	n_1	n_2	$\overline{X}$ (seconds)	r^2	95% Confidence Interval
Cruising	Calf (<1.8 m)	5	88	93.26	29.56	92.10- 94.42
While mother fed		2	163	92.47	38.09	91.50- 93.44
Suckling		4	49	116.86	122.15	113.70-120.02
Resting		7	230	104.20	91.13	102.94-105.46
Feeding (vegetation)		1	1	126.67		
Resting	Juvenile (1.8-2.6 m)	4	26	163.08	291.27	156.38-169.78
Nuzzling		1	1	212.31		
Feeding		3	3	170.00	1291.77	153.06-186.94
Cruising		1	1	75.00		
Cruising with calf	Adult (>2.6 m)	4	78	103.88	9.64	103.18-105.58
Cruising—no calf		5	22	116.39	604.01	105.91-126.87
Cruising—total		9	100	106.63	162.74	104.08-109.18
Feeding with calf		5	219	100.46	3174.95	92.84-108.08
Feeding—no calf		6	42	136.50	2456.37	121.18-141.82
Feeding—total		11	261	106.26	3226.92	99.23-113.29
Resting with calf		8	273	109.92	238.70	108.50-111.79
Resting—no calf		15	203	177.70	1926.69	171.54-183.86
Resting—total		23	476	138.83	2082.08	134.64-143.00
Nuzzling		3	17	157.06	2072.04	134.98-179.14
Nursing		3	29	99.21	62.30	96.28-102.14

SUBMERGENCE TIMES—The inequality observed in MST for each size class of manatee with activity would be expected because energy expenditure increases with greater activity. Also, MST was generally not equal for different sized individuals engaged in the same activity. There were exceptions to the latter generality, but they involved female manatees with calves, where coordination of breathing may have served to help the animals maintain contact with each other. These results support the findings of Moore (1951a), Parker (1922) and Hartman (1971, 1979).

The maximum submergence time for manatees at Blue Lagoon was 24 min, which is more than 7 min longer than the previous maximum dive time of 16 min 20 sec recorded by Parker (1922).

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VEGETATIONAL CHARACTERISTICS OF AN AGING RED MAPLE STAND AT SAWGRASS LAKE PARK, PINELLAS COUNTY, FLORIDA

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Abstract: Red maples presently dominate the swamp forest at Sawgrass Lake Park. Vegatational sampling showed, however, that the maple stand is aging as young maples are underrepresented. Underrepresentation is caused by high mortality of maple seedlings and young trees. One likely reason maples die prematurely is because they require moderately strong sunlight not available under the mature maple canopy. Evidence suggests that in recent years waters also have either been too high or too low in the swamp to permit seedling survival. Mesic hardwoods might be capable of replacing maples, but presently mesic species are not well represented in the swamp. Future use of the area for flood detention is likely to make the establishment and survival of mesic hardwoods even more difficult. Recommendations are made for improving conditions for hardwood survival in the existing maple swamp.

Sawgrass Lake Park, located 3.0 km north and 1.2 km west of downtown St. Petersburg, Florida encompasses the only extensive, nearly pure stand (~40 ha), of red maples *(Acer rubrum)* near the city (Rohwer and Woolfenden, 1969). The entire Park, totaling 134 ha, was acquired by the Southwest Florida Water Management District (SWFWMD) in 1975 for temporarily retaining floodwater runoff. Recently, the original land-use purpose was broadened when facilities for an environmental education program and for recreation were added. Of special interest is a mile-long boardwalk enabling park visitors to study what was formerly a nearly impenetrable swamp.

The initiation of multiple-use objectives in the Park resulted in conflicts with certain water management plans. For instance, retaining water in the swamp by means of a water control structure may stress certain plants. Conversely, at other times, control of waters on a channel bordering the swamp could lead to overdraining the swamplands. In Florida, overdraining can adversely affect forested wetlands by causing tree instability as organic soils subside.

To provide information on vegetational conditions in the swamp and to suggest ways to better manage swamp water levels, a plant monitoring program was begun by SWFWMD in 1978. The results of the present vegetational study make possible comparison with sampling results of 10 yr ago by Rohwer and Woolfenden (1969). They claimed the red maples were not reproducing.

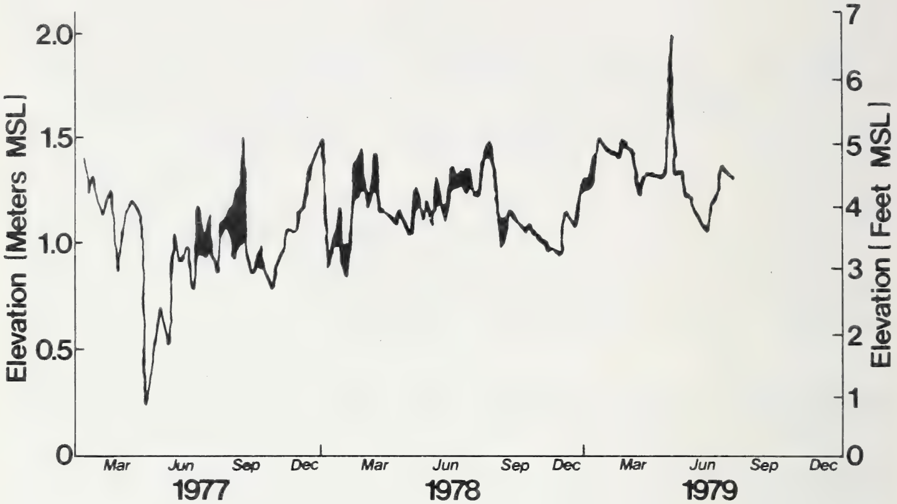

Fig. 1. Water levels for the period of record at the Sawgrass Lake water control structure.

Methods—Nine sites were chosen in the red maple swamp for study. Five sites were chosen randomly, while 4 were selected to provide more even coverage of the maple stand. Selection was facilitated by numbered stakes surveyed throughout the swamp at 61 m intervals to form a grid pattern. The sites were sampled in October-November 1978 and again in June-July 1979. Although exact water levels at the sites over the past several years are unknown, an approximation can be obtained from the hydrograph of Fig. 1 and the fact that sites ranged from 1.1 m (3.5 ft) msl to 1.5 m (5.0 ft) msl.

At each site a 6.1 × 12.2 m plot was used for tree sampling. Trees were defined as woody plants with a diameter at breast height (dbh) greater than 1.3 cm. Both dead and live trees were noted on the tree plots as well as a few large shrubs and vines with a dbh greater than 1.3 cm. Nested in a corner of each tree plot were 2.4 × 2.4 m and 1 × 1 m quadrats. Small shrubs and young trees $>$ 46 cm in height but $<$ 1.3 cm dbh were sampled on the 2.4 × 2.4 m quadrats. Herbs, ferns and tree seedlings were sampled on the 1 m^2 quadrat. The dbh of each tree was measured while shrubs and young trees were simply identified and counted. Percent cover of herbs, ferns and tree seedlings was estimated on the 1 m^2 quadrat. Frequency was calculated as follows:

$$\text{Frequency (percent)} = \frac{\text{No. Plots Present In}}{\text{Total Plots Sampled}} \times 100$$

Results—Results of fall 1978 and summer 1979 vegetational sampling are in Tables 1 and 2. These data revealed that red maple was overwhelmingly the most abundant tree in the swamp. Red maple also occurred throughout the swamp as shown by its 100% frequency of occurrence. The second and third most abundant trees were laurel oak *(Quercus laurifolia)* and red mulberry *(Morus rubra)*. Their joint abundance was only 8% of red maple and they occurred on only a third of the sampled plots.

The understory of the stand was dominated by Virginia willow *(Itea virginica)* and a few small laurel oaks (Table 1). Neither Virginia willow nor the laurel oak was evenly distributed through the swamp because the former occurred on only 1/3 of the sampled plots while the latter was on about a tenth of the plots. Dominating the ground cover were lizard's tail *(Saururus cernuus)*, royal ferns (*Osmunda regalis*), swamp ferns (*Thelypteris interrupta*) and green arum (*Peltandra virginica*). Red maple seedlings made up < 1% of the understory cover at both fall and summer samplings (Tables 1 and 2).

The vegetational composition of the swamp was similar at both fall 1978 and summer 1979 samplings (Tables 1 and 2). However, it was significant that only 4% of the maples sampled in the fall 1978 were dead while about 20% were dead in the summer 1979. Most of the red maple mortality occurred among saplings on a single plot although some dead trees occurred on 4 other plots.

A size-class analysis was made of red maples sampled on each of the 9 plots (Tables 3 and 4). Increment cores of the maples showed larger tree diameters were fairly consistently related to greater ages. Thus size-class analysis was roughly representative of an age-class analysis of the maples. Underlining in the Tables indicates underrepresentation in the smaller red maple size classes (where there were fewer individuals in a size class than in subsequent larger classes).

Underrepresentation was detected on all but one of the plots sampled in fall and summer. This was indicative of widespread failure of red maple recruitment throughout the swamp. In the future, the species most likely to replace the maples were laurel oak, water oak and dahoon. However, these trees were all presently smaller than 6 cm dbh, not very abundant, and patchy in their distribution (Tables 1 and 2).

Plot 138 differed from all others in that the maples were relatively small (mostly 1-6 cm) and the potential for recruitment into larger size classes appeared good. This site was located near a drainage canal and by all appearances the young maple stand had begun growth not many years ago after the area had been cleared of older growth. Interestingly, during the 9-mo interval between 1978 and 1979 samplings, about 1/2 the red maple saplings less than 6.2 cm dbh died on this plot while all older saplings and trees survived. Several of the dead saplings retained dry, dead leaves indicating they had leafed out sometime in the spring and later died. In May 1979, the Sawgrass Lake water detention area detained floodwaters from about a one-in-100 yr storm (Fig. 1) and high waters may have contributed to the death of the maple saplings.

The few young maple trees in the swamp cannot be attributed to failure

TABLE 1. Density and frequency of trees, shrubs and vines and coverage and frequency of ground cover, fall, 1978 sampling.

Trees		Density (per ha)	Frequency (percent)
Acer rubrum L.	red maple	1450 (live) 59 (dead)	100 22
Morus rubra L.	red mulberry	59	11
Quercus laurifolia Michx.	laurel oak	59	22
Sambucus simpsonii Rehder	southern elder berry	45	11
Ilex cassine L.	dahoon	30	22
Melia azedarach L.	china berry	15	11
Celtis laevigata Willd.	sugar berry	15	11
Shrubs, Vines and Small Trees		**Density (per ha)**	**Frequency (percent)**
Itea virginica L.	tassel white	3004	33
Quercus laurifolia Michx.	laurel oak	195	11
Psychotria sp.	wild coffee	15	11
Ampelopsis arborea (L.) Rusby	pepper vine	15	11
Ground Cover		**Coverage (percent)**	**Frequency (percent)**
Saururus cernuus L.	lizard's tail	8.4	44
Osmunda regalis L.	royal fern	3.9	44
Thelypteris interrupta (Willd.) Iwatsuki	swamp fern	1.6	22
Peltandra virginica (L.) Schott & Endl.	green arum	1.4	22
Blechnum serrulatum Richard	Blechnum fern	1.1	11
unidentified herbs		<1.0	100
Boehmeria cylindrica (L.) Sw.	false nettle	0.4	11
Acer rubrum L.	red maple	0.3	22
Itea virginica L.	tassel white	0.2	11
unidentified ferns		<0.2	22
Hydrocotyle umbellata L.	marsh pennywort	0.1	11

of seed germination because maple seedlings were very abundant in spring 1979. For instance, in April, 52 seedlings were counted on one 2.8 m dia circular plot in the understory and 209 on another. By June, only 1 seedling remained on the first plot and 23 seedlings on the second. This represented mortality of 89-98% during the spring.

DISCUSSION AND CONCLUSIONS—Although the swamp forest at Sawgrass Lake was dominated by red maples, the stand showed signs of aging. Under-representation of young maples was common and apparently was caused by high mortality of maple seedlings and young trees. Maples have not been

TABLE 2. Density and frequency of trees, shrubs and vines and coverage and frequency of ground cover, summer, 1979 sampling.

Trees		Density (per ha)	Frequency (percent)
Acer rubrum L.	red maple	1270 (live) 329 (dead)	100
Morus rubra L.	red mulberry	59	11
Quercus laurifolia Michx.	laurel oak	45	22
Ilex cassine L.	dahoon	30	22
Sambucus simpsonii Rehder	southern elder berry	30	11
Melia azedarach L.	china berry	15	11
Celtis laevigata Willd.	sugar berry	15	11
Quercus nigra L.	water oak	15	11

Shrubs and Vines		Density (per ha)	Frequency (percent)
Itea virginica L.	tassel white	3392	33
Psychotria sp.	wild coffee	15	11
Ampelopsis arborea (L.) Rusby	pepper vine	15	11

Ground Cover		Coverage (percent)	Freqency (percent)
Saururus cernuus L.	lizard's tail	11.7	44
Osmunda regalis L.	royal fern	8.4	56
Thelypteris interrupta (Willd.) Iwatsuki	swamp fern	5.6	11
Peltandra virginica (L.) Schott & Endl.	green arum	4.4	22
Blechnum serrulatum Richard	blechnum fern	2.2	11
Hydrocotyle umbellata L.	marsh pennywort	0.6	11
Itea virginica L.	tassel white	0.6	11
Lemna sp.	duckweed	<0.2	22
unidentified ferns		<0.2	22
Acer rubrum L.	red maple	0.1	11
Galium sp.	bedstraw	<0.1	11
unidentified herbs		<0.1	11

reproducing for some time, since Rohwer and Woolfenden (1969) made this same observation at Sawgrass Lake 10 yr ago.

Mortality of young maples was attributed to several factors. First, red maple trees require moderately strong sunlight (Daubenmire, 1959). Hence, young trees may die prematurely under the mature maple canopy at Sawgrass Lake. Secondly, red maple is only of intermediate flood tolerance (Teskey and Hinckley, 1977). Therefore, floodwater surges detained in the area could have exceeded the tolerance of maple seedlings and saplings. Finally, red maple in the southern part of its range requires fairly moist soil conditions (Fowells, 1965). In the past several years swamp waters have

TABLE 3. Size class distributions of live and dead red maples on 9 plots, fall, 1978 sampling. Underlining indicates underrepresentation of live red maples (see text).

	Diameter Breast High (DBH) Intervals (cm)							
Status	1.3-6.2	6.2-11.3	11.3-16.4	16.4-21.5	21.5-26.5	26.5-31.6	31.6-36.7	36.7-41.8
PLOT 31								
Live red maples	—	2	2	5	1			
Dead red maples	1	2						
PLOT 35								
Live red maples	—	—	1	1	1	1		
Dead red maples								
PLOT 13								
Live red maples	—	—	—	—	2		2	
Dead red maples								
PLOT 66								
Live red maples	—	1	2	3	5	1		
Dead red maples								
PLOT 91								
Live red maples	—	3		2	1	1		2
Dead red maples								
PLOT 119								
Live red maples	5	—	1	1		1		
Dead red maples								
PLOT 181								
Live red maples	—	—	—	1				
Dead red maples		1						
PLOT 174								
Live red maples	1	—	—	1	2	1	1	
Dead red maples								
PLOT 138								
Live red maples	36	6	1					
Dead red maples								

been intentionally lowered to facilitate fencing and construction of the boardwalk and control structure. Therefore, relatively dry conditions may have stressed young maples and led to their premature death.

Under natural conditions in this part of Florida, a declining red maple stand might be replaced in time by a climax community of oak, southern magnolia and other mesic hardwoods (Ward, 1980). At Sawgrass Lake the scarcity of oak and other potential hardwood replacements can likely be at-

TABLE 4. Size class distributions of live and dead red maples on 9 plots, summer, 1979 sampling. Underlining indicates underrepresentation of live red maples (see text).

	Diameter Breast High (DBH) Intervals (cm)							
Status	1.3-6.2	6.2-11.3	11.3-16.4	16.4-21.5	21.5-26.5	26.5-31.6	31.6-36.7	36.7-41.8
PLOT 31								
Live red maples	—	1	1	3	3			
Dead red maples	1	3	1					
PLOT 35								
Live red maples	—	—	1		2	1		
Dead red maples								
PLOT 13								
Live red maples	—	—	—	—	2	1	1	
Dead red maples								
PLOT 66								
Live red maples	—	1	2	3	5	1		
Dead red maples								
PLOT 91								
Live red maples	—	1		2	1	1		2
Dead red maples		2						
PLOT 119								
Live red maples	5	—	—	2			1	
Dead red maples								
PLOT 181								
Live red maples	—	—	—	—	1		1	
Dead red maples		1						
PLOT 174								
Live red maples	1	1	—	1	2		2	
Dead red maples	1							
PLOT 138								
Live red maples	27	6	1					
Dead red maples	13							

tributed to the periodic occurrence of high water levels in the swamp during the past several years. Utilization of the flood-detention capability of the swamp in future years is certain to make survival difficult or impossible for mesic hardwoods.

As the Sawgrass Lake red maple stand ages, the failure to replace overstory trees will lead to a thinning of the maple canopy. Underrepresentation of canopy species in moist streambottom stands has been reported from the Alabama piedmont (Golden, 1979) and for mesic and wet Coastal Plain forest stands of southeast Texas (Harcombe and Marks, 1978). Both studies suggested that low seedling and or sapling survival can lead to small-to-intermediate sized gaps in the canopy. Within these gaps intermediately shade-tolerant trees, such as certain oaks and hickories, might survive to maintain an oak-hickory climax. Whether similar events could occur in gaps in the maple stand of Sawgrass Lake remains to be seen.

Assuming water will be intermittently held in the Sawgrass Lake Flood Detention Area, thus making natural succession toward a hammock difficult or impossible, I recommend 2 steps toward improving conditions in the existing maple swamp. First, that insofar as possible structural control be directed toward reducing surges of high water that stress red maple seedlings and saplings. At the same time, swamp waters should remain close enough to ground surface to maintain soil moisture and prevent excessive drought stress in the maples. Secondly, at times of the year when flooding maple seedlings is not a problem, several inches of water should be maintained in the swamp to lessen the problem of soil subsidence.

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GOFF'S POCKET GOPHER *(GEOMYS PINETIS GOFFI)* IS EXTINCT—*Stephen R. Humphrey*, Florida State Museum, University of Florida, Gainesville, Florida 32611

ABSTRACT: *All recorded sites and potential habitat of* G. p. goffi *were surveyed and the history of its distribution was reviewed. The former range of the taxon is now a city, and no gopher mounds were found there or in surrounding habitat.*

GOFF'S POCKET GOPHER is known from 22 specimens taken between 1897 and 1955. Apparently the subspecies has not been seen by a biologist since then. An attempt to find gopher mounds in the appropriate area in 1974 was unsuccessful (Ehrhart, 1978).

Records of *G. p. goffi* are known only from the type locality. This range is described by Sherman (1944) as " . . . part of a strip of Norfolk and St. Lucie fine sands which border the Indian River [Brevard Co., Florida]. Evidence of *Geomys* has been found for a distance of about two miles inland from the Indian River."

The habitat of *G. p. goffi* was described as follows: "The large colony at Eau Gallie, that occupies the extensive white sand ridges about the town, is, I believe, the most southern colony of any size, although I have heard of its hills being seen even south of Micco" (Bangs, 1898).

METHODS—Searches for gopher mounds were conducted on foot and by jeep on 19-20 October 1978, 16 November 1978, 14 January 1979, 17 January 1979, and March 1979. Searches for gopher mounds were conducted by light aircraft on 16 November 1978 and 14 January 1979. The airplane was flown at an elevation of 150 m. The area searched was defined as the entire Pineda Ridge, including all areas with soil deep enough to support sand pine *(Pinus clausa)* or longleaf pine *(P. palustris)* associations. The Pineda Ridge is wide at the south end near Malabar, bounded by the south edge of T 28 S and spanning most of R 38 E and R 36 E. The ridge narrows to the north and stops north of Bonaventure in the center of section 23, T 25 S, R 36 E. Labels of museum specimens were examined for detailed locality data. Local residents, naturalists, and Wildlife Conservation Officers were asked about any observations they might have made of gopher mounds.

RESULTS AND DISCUSSION—The type locality around Eau Gallie (now part of Melbourne) has been converted to urban and suburban land uses, except for the fenced grounds of Melbourne Regional (John F. Kennedy) Airport. The airport property was included in the search. One specimen label referred to "Lemon Street." This street name no longer exists, but an "Orange Street" was found in old downtown Eau Gallie and a "Citrus Street" was found about 4 km WNW of the town. A substantial amount of suitable pocket gopher habitat was noted in the Eau Gallie portion of Melbourne and elsewhere along Pineda Ridge, in the form of roadsides, railroad right-of-way, a few pastures, fields along airport runways, parks, golf courses, baseball fields, and cemeteries. Most native habitat was very mature, with a closed canopy and a dense oak understory in sand pine forest and a dense understory of palmetto in longleaf pine areas.

No pocket gopher mounds were found within the type locality nor anywhere else on the Pineda Ridge. The survey was considered complete. Suspect items seen from the air proved to be such things as cow droppings and lids from 19 liter cans (36 cm in dia), so flight elevation was judged low enough for detection of pocket gopher mounds. Mounds would not have been visible from the air in mature native habitats because of the density of cover above the ground. However, walks through substantial areas of these habitats led to the conclusion that too little groundstory vegetation existed in them to support foraging pocket gophers. To eliminate the possibility that gophers survived in openings made in native habitat by disturbance from off-road vehicles, all jeep or bike trails that could be found were transversed by vehicle or on foot. No valid reports of gophers were received from local people.

It is not clear what has happened to *G. p. goffi* or its habitat. The subspecies was considered abundant by Bangs (1898), and it seems unlikely that the collection of 22 specimens would have resulted in extinction, without other factors involved. The only living biologist who has seen *G. p. goffi* in the field is Dr. Al Schwartz of Miami-Dade Community College. He collected 2 specimens on 31 December 1955. In a day of search, he found only 1 small colony (a few mounds) in an uncleared lot within a new housing development on the outskirts of the town of Eau Gallie (pers. comm.). This site was less than 1 km from the old downtown area. This observation is the last record of an extant population. The rapid development in the Eau Gallie area since then would have disrupted gopher populations. Undeveloped habitats on Pineda Ridge have been protected from wildfire because of the numerous nearby houses, rendering both sand pine and longleaf pine woods too mature for healthy gopher populations. No other clues to the fate of *G. p. goffi* are apparent. I concur with the conclusion of Ehrhart (1978) that *G. p. goffi* is extinct.

ACKNOWLEDGMENTS—This work was conducted as a contract study for the Endangered Species Program of the Florida Game and Fresh Water Fish Commission and as such was partially financed with grant-in-aid funds under Section 6 of the Endangered Species Act of 1973 (PL 93-205). I thank Don A. Wood for encouragement and administrative support and, along with Kenneth T. Wilkins, for assistance in the field.

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NEW RECORDS OF THE SPOTTED TURTLE, *CLEMMYS GUTTATA* IN NORTHERN FLORIDA—*Leroy H. Banicki*, Department of Biological Sciences, University of Texas at El Paso, El Paso, Texas 79968

Abstract: *Six additional records of* Clemmys guttata, *including the first report for St. John's County, supplement the spotty distribution of this species in northern Florida as summarized by Berry and Gidden (1974).*

Since Berry and Gidden's study (1974) of *Clemmys guttata* in Florida and southern Georgia, records of only 6 adults have become available from northern Florida. Three of these 6 turtles are deposited in the Florida State Museum; their data of collection are: 1) UF 39967, on SR 20A between Cowpen and McMeekin lakes, Putnam County, C. R. Smith, 20 May 1977; 2) UF 48933, within the city limits of Gainesville, Alachua County, K. Bjorndahl, 1975; 3) UF 49253, on SR 19, 0.1 mi N junction Buckman Lock Road, Putnam County, Frank Brandt, 20 March 1980. There is a reliable report from Dave Bowman (U.S. Army Corps of Engineers, Orange Springs, Florida), who caught and released 2 specimens in the same vicinity as the locality for UF 39967. The author found a specimen (currently in captivity, but to be deposited in the Florida State Museum) in St. John's County on SR 210, 3.1 mi W of U.S. Highway 95 on 9 March 1980; the specimen represents the first record for the county and extends the known range of *C. guttata* in Florida about 15 mi eastward. Berry and Gidden (1974) omitted reference to a newspaper article ("Pair of Spotted Turtles Found in Area", *Gainesville Sun*, 8 May 1970) of 2 *C. guttata* collected by Charles Buchanan between Melrose and Gainesville at the first curve east of the Windsor intersection on SR 26; the 2 specimens were subsequently exhibited by West Patterson in Melrose, but their present status is unknown.

Some authors (Neill, 1954; Ernst, 1972; and Pritchard, 1979) question whether *C. guttata* is truly native to Florida. However, Dr. Steve Christman (National Fish and Wildlife Laboratory, Gainesville) is convinced the species is established in Florida and is optimistic about finding specimens in the sand hills lakes of Putnam County (pers. comm.). Berry and Gidden (1974) reported several *C. guttata* being taken on SR 59, St. Marks National Wildlife Refuge, Wakulla County. Although no specimens have been taken since 1975, Berry (1978), Dr. Bruce Means (pers. comm.), and Culver Gidden (pers. comm.) are convinced the species is established on the St. Marks National Wildlife Refuge.

C. guttata seems to occur in limited numbers, and additional collecting is necessary to determine its status, range, and habitat preferences in northern Florida.

Acknowledgments—The author thanks Dr. Steve Christman, National Fish and Wildlife Laboratory, Gainesville, Florida; Culver Gidden, St. Marks National Wildlife Refuge, St. Marks, Florida; and Dr. Bruce Means, Tall Timbers Research Station, Tallahassee, Florida for their data and helpful suggestions. Thanks also to Dr. Robert G. Webb, University of Texas at El Paso, Texas, for reviewing the manuscript and offering many helpful suggestions. Special thanks to Peter Meylan, Florida State Museum, University of Florida, Gainesville, Florida, for supplying the author with valuable data and for his support and encouragement.

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Florida Sci. 44(4): 253-254. 1981.

Outstanding Scientist Award

CITATION FOR HAROLD J. HUMM

HAROLD J. HUMM is well-known in marine biology circles everywhere for his important work on the distribution, taxonomy, and utilization of marine algae and in marine bacteriology. Much of this work has been done in Florida and some in North Carolina as we shall see.

Harold Humm was born in Lorain, Ohio in 1912. Evidently his parents moved to Florida, because he graduated from the University of Miami in 1934, receiving a B.S. with major in botany. His graduate education was obtained at Duke University, where he received the M.S. in 1942 and a Ph.D. in 1945, with majors in botany and bacteriology. He was on the staff of Duke University Marine Laboratory for several years, serving as its director in 1948-49.

In 1949 Dr. Humm returned to Florida as director of the Oceanographic Institute at Florida State University. After 5 yr he returned to Duke as an associate professor of botany for 11 yr, and then served for 2 yr as professor of botany at Queens College in Charlotte, North Carolina.

In 1967 he returned again to Florida, this time for good, we trust! He went to the University of South Florida as professor of marine science and first director of its Marine Science Institute in St. Petersburg. He served as director for 7 yr, and continues as professor. Thus, over 20 yr of Dr. Humm's professional life have been spent in the Sunshine State.

Our medalist has been a visiting scientist at many marine laboratories. He has been active in both civic and professional organizations, for example as President of the Association of Southeastern Biologists in 1967. He has received numerous honors and awards, including having some 10 marine organisms named in his honor. His publication record is awesome: it includes 3 books and some 100 articles, over half of which are in referred scientific journals; the others are chapters in books, items in encyclopedias, notes in proceedings or bulletins of academies, corporations, etc. His research, including that of some of his colleagues, has been supported by grants and contracts from the National Science Foundation as well as other governmental and industrial organizations.

There are many workers in marine biology today who remember Dr. Humm as their beloved and valued guide and teacher. This is perhaps his greatest professional contribution: Over 20 individuals have received advanced degrees (M.S., Ph.D.) under his guidance, and many others have been inspired and motivated by his teaching and his exemplary dedication to research. His warm personality and his vast knowledge of natural history have attracted many students into the growing field of marine science.

The Florida Academy of Sciences wishes to further honor *Harold J. Humm* with its 1981 medal.

REVIEW

Francis Harper and Delma E. Presley. *Okefinokee Album.* Pp. i-xvii, 1-194. (30 March 1981), University of Georgia Press, Athens. Price: $14.95.

THIS delightful book stems from notes made by Francis Harper during his many visits to the Okefinokee Swamp (the time-honored spelling of Okefinokee instead of Okefenokee is retained and discussed in detail). The legacy started in 1912 as scribblings by the young Cornell naturalist on a biological reconnaissance to the area and culminated with Harper's last entry in his Okefinokee notebooks (30 volumes) in 1951. Although Francis Harper had long wanted to write a book on the environs and events of the famous Georgia swamp, his project never materialized; Harper died on 17 November 1972. Fortunately, he kept detailed notes and from these, along with the help of Harper's wife, Jean, and their two sons, Robin and David, Delma E. Presley has successfully formulated this book. Major divisions of *Okefinokee Album* are: Francis Harper and the People of the Great Swamp; The Way to Billys Island; Okefinokee Sampler; Okefinokee Folk; Potions, Portents, Ballads, and Tales; Okefinokee Album; Swamp Talk; Of Mammals and Birds; Chessers Island Journal; and Notes on a Vanishing Breed. The latter is a postscript by Delma E. Presley. Concluding the book is a bibliography entitled "Works on the Okefinokee" which includes the writings of Harper and other researchers.

Francis Harper was truly a man of tremendous energy and ability. After he received his Ph.D. from Cornell in 1925, he became an employee of the Boston Society of Natural History. In 1929 he joined the staff of *Biological Abstracts* in Philadelphia, where he remained until 1935. Other experiences include: research associate with the American Committee for International Wildlife Protection and the John Bartram Association, member of the editorial staff of the American Philosophical Society in Philadelphia, agent for the Reading, Pennsylvania, Public Museum and Art Gallery, and member of the staff of the E. N. Huyck Preserve, Rensselaerville, New York. Among the 135 articles, monographs, and books on natural history written by Harper, his naturalist's edition on *The Travels of William Bartram* (Yale University Press, 1958) is perhaps the best known. With the completion of his book, Francis Harper had turned his attention to his Okefinokee collection.

Okefinokee Album intermeshes the landscape and wildlife with the people who lived in the swamp—the swampers are now gone and nearly forgotten. Surnames include Chesser, Lee, Thrift, Mizell, Roddenberry, Henderson, Spaulding, Gibson, Cox, and Crew. I am sure folklore enthusiasts and even some genealogists and anthropologists will find the book interesting in addition to the naturalist type. A major asset of *Okefinokee Album* is the large collection of excellent photographs on display. All were taken by Harper and his wife Jean.

It certainly was a joy for me to turn the pages of *Okefinokee Album.* I am sure you will want to do the same.—*Walter Kingsley Taylor*, Department of Biological Sciences, University of Central Florida, Orlando, Florida 32816.

Florida Scientist

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Individuals who publish in the *Florida Scientist* must be active members in the Florida Academy of Sciences.

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ACKNOWLEDGMENTS are given in the body of the text preceding immediately the Literature Cited section.

LITERATURE CITED section follows the text. Double-space every line and follow the format in the current issue.

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Volume 44 Supplement 1

Program Issue

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1981

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FORTY-FIFTH ANNUAL MEETING OF THE FLORIDA ACADEMY OF SCIENCES

at the

JOHN YOUNG MUSEUM AND PLANETARIUM, LOCH HAVEN PARK, ORLANDO

30 April and 1, 2 May 1981

All registrants for meetings of the Senior and Junior Academy and the Florida Section of the American Association of Physics Teachers are welcome to attend all sessions of all organizations.

John Young Museum and Planetarium, Loch Haven Park

Loch Haven Park is located between I-4 and highway 17-92 on the shores of Lake Estelle, which is bisected by Mills Avenue (highway 17-92). The Park can be reached from I-4 by taking the Princeton Street-Loch Haven Park exit east 0.6 miles; Princeton Street passes through the Park and ends at Mills Avenue. For participants arriving from the north on highway 17-92, the highway is called Orlando Avenue in Winter Park and becomes Mills Avenue at the Orlando-Winter Park city limits near the Museum. Participants may use the brick parking lot between the Museum and the Loch Haven Art Center. Refer to the maps on the outside and inside back cover.

Meetings will be held at the John Young Museum and Planetarium and at the Junior Achievement Center, located southwest of the Museum across Princeton Avenue. Registrants are invited to view exhibits of the Museum during breaks and between sessions. Tickets for programs held in the Planetarium can be purchased for $1.75 at the ticket booth.

Registration

A registration desk will be operated in the lobby of the John Young Museum and Planetarium from 7:00 pm to 9:00 pm on Thursday, 30 April, from 7:30 am to 4:00 pm on Friday, 1 May, and from 7:30 am to 3:00 pm on Saturday, 2 May.

The registration fee is $5.00 for members. The fee for non-members is $7.00 and includes the Florida Scientist Program Issue. The fee is waived for students; programs are available for $2.00.

Lodging

The motels listed below are within 2 miles of Loch Haven Park. No reservations can be arranged by the Academy. Please make reservations as soon as possible by contacting the facility of your choice. A deposit of one night's rent or a credit card number might be requested, especially if you expect late (after 4:00 pm) arrival. Rates given below are the "convention rates" quoted by the motels in March 1981. Be certain to identify yourself as a member of FAS. Check-in time is after 1:00 pm and check-out before 11:00 am.

	Mt. Vernon Motor Lodge 110 S. Orlando Ave. Winter Park 305-647-1166	Orlando Motor Lodge 1825 N. Mills Ave. Orlando 305-896-4111	Quality Inn Orlando Ave. & Lee Winter Park 305-644-8000
1 person/1 bed	$25	$18	$20
2/1	not available	$18	$26
2/2	$29	$24	$26
Extra person	each $ 4	each $ 3	included $28
2 extra			included $32
Cot	no charge	$ 2	not available
Children	inquire	inquire	<16 yr free if w/parent
Reserve by	15 April	8 April	15 April
Contact	Cathy Ryan	any clerk	Ms. Brooks

Food Service

Information about nearby food services will be available at the registration desk.

Stand-Ins and Cancellations

If the author or a coauthor of a scheduled paper cannot present the paper due to illness, unforeseen conflict, or other circumstance, the author should arrange for a colleague to read the abstracted paper. If a reader cannot be enlisted, the paper should be cancelled. The Academy should be notified about a reader or an intent to cancel. Early notification will allow inclusion of the change in a program supplement and will spare the author of a cancelled paper the embarrassment of an apparent no-show.

Contact (in preferred order) R. L. Turner, Program Chairman (305-723-3701, ext. 262), Joyce Powers at the Academy office (305-896-7151), the section chairman, or the presider of the session.

Field Trip

A field trip to the Tosohatchee State Preserve, near Christmas, Florida, is scheduled for Saturday afternoon. The Tosohatchee is a remarkably diverse and well-preserved tract that includes oak-palm hammocks, pine flatwoods (including 40 acres of virgin pine), extensive virgin cypress swamps and St. Johns River marsh. Three tannin-stained streams (Tosohatchee Creek, Jim Creek, and Taylor Creek) flow through the area. A number of Indian mounds on bluffs along the St. Johns River and elsewhere and a large, rustic hunting lodge built in 1912 contribute to the historical interest of the preserve. The trip will be led by Dr. L. M. Ehrhart, University of Central Florida, and Mr. Jon Doderill, District Naturalist with the Division of Parks and Recreation, Florida Department of Natural Resources.

Meet in the parking lot of the John Young Museum and Planetarium at 1:15 pm. Drivers may be asked to cooperate in taking passengers. Estimated time of return to JYMP is 6:00 pm.

Announcements

BIOLOGICAL SCIENCES. The Section officers have prepared a slate of two nominees for Chairman-Elect. Brief descriptions of the candidates' credentials are posted at the FAS registration desk. Additional nominations will be accepted from the floor during the Section's business meeting at 11:00 am Friday.

FLORIDA JUNIOR ACADEMY OF SCIENCES and SCIENCE TALENT SEARCH. Members of the Senior Academy are needed as judges for the FJAS paper sessions on Friday and as interviewers for the Talent Search on Saturday. If you would be willing to serve for part or all of a morning or afternoon, please contact Dorothy Henley, Cardinal Gibbons High School, 4520 N.E. 15th Terrace, Ft. Lauderdale, FL 33334 (305-772-4836, after 3:00 pm) or the Academy office (305-896-7151). Information on where judges are needed will also be provided at the FAS and JFAS registration desks.

JOINT PROGRAMS. The following sections are conducting joint programs, and their chairmen have requested joint business meetings: ATMOSPHERIC AND OCEANOGRAPHIC SCIENCES and PHYSICAL SCIENCES; SOCIAL SCIENCES and URBAN AND REGIONAL PLANNING.

POSTER SESSION. Poster presentations will be on display from 9:30 am to 3:00 pm in the hallway between Alpha and Beta rooms in the John Young Museum and Planetarium on Saturday. The four entries are listed in the program as BIO-48 through BIO-51.

SPECIAL PRESENTATION. The GEOLOGY AND HYDROLOGY and SCIENCE TEACHING sections are sponsoring a special presentation by Frank B. Kujawa, "The Geology of U.S. National Parks through Six-Screen Panoramas" at 12:45 pm, Friday in The Blalock Auditorium of the John Young Museum and Planetarium. All participants are invited to attend. For those who are interested, Dr. Kujawa will present a paper (GHY-30) later about techniques used to produce the panoramas.

SPECIAL SESSIONS. The following sections have arranged special sessions (15-min invited papers arranged specially for the section). ANTHROPOLOGICAL SCIENCES and BIOLOGICAL SCIENCES: "Methods of Data Collecting in the Behavioral Sciences". ANTHROPOLOGICAL SCIENCES: "Archaeology of Inland Tampa Bay", "Archaeology of South Florida", "Microethnography". ENVIRONMENTAL CHEMISTRY: "Management of Undesirable Organisms by Natural Means."

ACKNOWLEDGEMENTS. The Program Chairman appreciates the help of the following in the technical preparation of the program issue: K. C. Cook. H. A. Lena-Hernandez, M. J. Konicki, D. Looney, J. E. Powers, and D. R. Turner.

PROGRAM SUMMARY

THURSDAY AFTERNOON, 30 APRIL 1981

2:00 pm	COUNCIL MEETING	Alpha
7:00 pm	REGISTRATION (to 9:00 pm)	Lobby

FRIDAY MORNING, 1 MAY 1981

7:30 am	REGISTRATION	Lobby
8:00 am	Environmental Chemistry A	Strates
8:15 am	Biological Sciences B	Beta
8:30 am	Biological Sciences A	Alpha
8:30 am	Geology and Hydrology A	JAC 1
8:30 am	Geology and Hydrology B	JAC 2
9:00 am	Anthropological Sciences A	Lab.
9:00 am	Engineering	JAC 3
10:15 am	Medical Sciences	Lab.
11:00 am	BUSINESS MEETINGS	
	Agricultural Science	Alpha
	Biological Sciences	Beta
	Engineering	JAC 3
	Geology and Hydrology	JAC 1
	Science Teaching	JAC 2
11:30 am	BUSINESS MEETINGS	
	Environmental Chemistry	Strates
	Medical Sciences	Lab.

FRIDAY AFTERNOON, 1 MAY 1981

12:00 n	REGISTRATION (to 4:00 pm)	Lobby
12:45 pm	Geology Hydrology/Science Teaching: Special Presentation	Aud.
1:30 pm	PLENARY SESSION	Aud.
2:55 pm	Florida Committee on Rare/Endangered Plants/Animals A	Alpha
3:00 pm	Anthropological/Biological Sciences: Joint Special Session	Lab.
3:00 pm	Biological Sciences C	Beta
3:00 pm	Environmental Chemistry B	Strates
3:00 pm	Geology and Hydrology C	JAC 1
3:00 pm	Geology and Hydrology D	JAC 2

SATURDAY MORNING, 2 MAY 1981

7:30 am	REGISTRATION	Lobby
8:00 am	Anthropological Sciences B	Lab.
8:30 am	Social Sciences/Urban and Regional Planning A	JAC 1
9:00 am	American Association of Physics Teachers	JAC 3
9:00 am	Atmospheric and Oceanographic/Physical Sciences	JAC 2
9:00 am	Biological Sciences D	Alpha
9:00 am	Biological Sciences E	Beta
9:00 am	Florida Committee on Rare/Endangered Plants/Animals B	Strates
9:30 am	Biological Sciences F	Hall
9:45 am	Social Sciences/Urban and Regional Planning B	JAC 1
10:00 am	Anthropological Sciences C	Lab.
11:00 am	BUSINESS MEETINGS	
	Atmospheric and Oceanographic/Physical Sciences	JAC 2
	Florida Committee on Rare/Endangered Plants/Animals	Strates
	Social Sciences/Urban and Regional Planning	JAC 1

SATURDAY AFTERNOON, 2 MAY 1981

12:00 n	REGISTRATION (to 3:00 pm)	Lobby
12:15 pm	BUSINESS MEETING: American Association of Physics Teachers	JAC 3
1:00 pm	Antrhopological Sciences D	Lab.
1:15 pm	FIELD TRIP: Tosohatchee State Preserve	JYMP Parking Lot
1:30 pm	Biological Sciences G	Beta
1:30 pm	Biological Sciences H	Alpha
3:00 pm	Anthropological Sciences E	Lab.
4:00 pm	BUSINESS MEETING: Anthropological Sciences	Lab.

ROOM ABBREVIATIONS: John Young Museum and Planetarium (JYMP)--ALPHA and BETA rooms, The Blalock AUDitorium, HALLway, LABoratory, LOBBY, The E. James STRATES Room; Junior Achievement Center (JAC)--rooms 1, 2, and 3.

PLENARY SESSION OF THE FLORIDA ACADEMY OF SCIENCES

Harvey A. Miller

President

Friday, 1 May 1981

The Blalock Auditorium

John Young Museum and Planetarium

1:30 pm

WELCOMING REMARKS

Mark E. Sinclair
Director
John Young Museum and Planetarium

1:35 pm

JUPITER, SATURN, AND BEYOND

Thomas D. Carr, Ph.D.
1980 F.A.S. Medalist
Department of Astronomy
Bryant Space Sciences Research Building
University of Florida

2:20 pm

PRESENTATION OF THE 1981 F.A.S. MEDALIST AWARD

2:30 pm

BUSINESS MEETING OF THE ACADEMY

NOTES

AGRICULTURAL SCIENCE

FRIDAY 11:00 am John Young Museum and Planetarium, Alpha Room

BUSINESS MEETING: Agricultural Science Section

(Abstract transmitted to Biological Sciences Section)

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

AMERICAN ASSOCIATION OF PHYSICS TEACHERS, FLORIDA SECTION

SATURDAY 9:00 am Junior Achievement Center, Room 3

JOSEPH L. AUBEL, University of South Florida, presiding

9:00 am APT-1 Measurement of Very Low Level Radioactivity in the Environment from PRC Weapons Tests. RALPH A. LLEWELLYN, University of Central Florida. A multi-dimensional gamma ray spectrometer was used to measure the concentration of specific radionuclides in the atmosphere over the central United States as a consequence of the current series of nuclear weapons tests being conducted by the Peoples Republic of China. Whole body exposures were found to be significant. Similar techniques can be used for measuring the radioactive fallout from coal-fired electric generating stations

9:15 am APT-2 Problems in Calculating the Gravitational Force Between Two Thin Disks. M. WOODYARD AND W. OELFKE, University of Central Florida. The problem of choosing the best technique to use to numberically compute the multiple integral that represents the gravitational force between two disks will be discussed, along with its application in a short-range Cavendish experiment.

9:30 am APT-3 Factors That Determine the Tone Quality of a Violin. GUIDO M. ZIMMER, Niceville High School, FL. (AAPT acoustics prize winner at the International Science Fair, St. Paul, MN.)

9:45 am APT-4 A New Holographic Laboratory. STANLEY S. BALLARD, University of Florida. We have built up an instructional laboratory in holography, to follow the largely descriptive course "Light, Color, and Holography." There are two laboratory rooms and a separate photographic darkroom. Each lab room is equipped with a He-Ne laser and two isolation (vibration-free) tables. The tables were constructed in our research machine shop, as was much of the auxiliary equipment. Details are discussed.

10:00 am APT-5 A Student Laser Project. J.H. NOON, University of Central Florida. A project underway involving several students in building a pulsed dye laser with several watts intensity from components of moderate cost will be described. Procedure follows suggestions originated by A.J. Alfrey. * Construction of the elliptical cavity, dye cell, power supply and optical resonator will be discussed. (*A.J. Alfredy, "Constructing Simple Flashlamp Pumped Dye Lasers," Labworks Press, Los Angeles, CA (1980).)

10:15 am APT-6 Effective Lower Division Laboratory. JAMES G. POTTER, Florida Institute of Technology. The learning experiences which need to be gained through laboratory work have been found to be provided most effectively by providing a manual with detailed procedures in steps in which a student is forced to do detailed resourceful critical thinking about his procedures, findings, uncertainties in data , and the implications of the extent of disagreements in his results. The most effective experiments seem to be the less sophisticated experiments employing mostly standard instruments and equipment relatively simple to fabricate.

10:30 am BREAK

10:45 am APT-7 Computer(ing) on a Tight Budget - Alternatives to the Commercially Available Micro's. J.A. MEYERS, University of Central Florida, Physics Department, Orlando, FL 32816. A short course on resources for building your own microcomputer cheaply. Discuss how interfacing and the operating system are the keys to understanding computer systems.

11:00 am APT-8 Microcomputers in the High School Physics Classroom. J.J. BRENNAN AND J.A. MEYERS, University of Central Florida, Physics Department, Orlando, FL 32816. An overview of relevant computer literature and hardware available will be given. Number crunching, graphics and experimenting on the computer will be discussed. A comparison of home microcomputer systems will be made.

11:15 am APT-9 STARS Physical Science at Seminole Community College*. A.K. DICKISON, Seminole Community College , Sanford, FL 32771. During Fall Semester, special Physical Science class was taught that incorporated instructional techniques aimed to develop improved reasoning skills in entering freshmen. This paper will explain the course and give preliminary findings.(*Partially funded by the Fund for the Improvement of Science Ed.)

11:30 am APT-10 A Better Way to Teach Lecture Courses. J.L. AUBEL, University of South Florida. Some of the advantages of a competency-based approach to teaching General Physics* can be retained in a conventional lecture setting. Weekly tests and written course notes seem to be key factors in an apparent improvement in student performance. A computer record-keeping program will be discussed. (*J.L. Aubel, Am. J. Phy. 42, 1101 (1974))

11:45 am APT-11 Physics Olympics, 1981. BEN LYND AND BILL MCCORD, Valencia Community College; ALEX DICKISON, Seminole Community College; MARTIN HUDSON, University of Central Florida. Review and highlights of the 1981 Central Florida Physics Olympics, which is sponsored by AAPT-Fla. Section, will be presented

12:00 n APT-12 The Recent New York Meeting of AAPT. ALEX DICKISON, Seminole Community College, Sanford, FL 32771. Highlights are presented of the joint annual AAPT-APS meeting held in New York City on January 25-29,1981.

SATURDAY 12:15 pm Junior Achievement Center, Room 3

BUSINESS MEETING: American Association of Physics Teachers, Florida Section

FRANK A. ANDERSON, The Bolles School, presiding

ANTHROPOLOGICAL SCIENCES

FRIDAY 9:00 am John Young Museum and Planetarium, Laboratory

SESSION A: Biological Anthropology

CURTIS W. WIENKER, University of South Florida, presiding

9:00 am ANS-1 Contemporary Applied Physical Anthropology in America. CURTIS W. WIENKER, University of South Florida, Tampa, FL 33620. A brief history of modern (20th Century) applied physical anthropology in America is presented. While earlier efforts concentrated largely in the area of human engineering and anthropometry, recently forensic anthropology (human identification) has blossomed as an applied field of modern physical anthropology.

Data are presented which document the expanding role of applied physical anthropology, especially in modern biomedical contexts. Data demonstrate the increasing necessity of physical anthropologists to gain expertese in biomedical fields to maximize their career potentials. Importantly, the unique approach of modern physical anthropology insures that it will grow in prominence as an applied discipline in the future. Some of the most important interfaces between physical anthropology and modern biomedical problems, including cancer and cardiovascular disease are discussed.

9:15 am ANS-2 Facial Reconstruction from the Skull: A Follow-up. M. YAŞAR ISCAN, Florida Atlantic University, Boca Raton, FL. 33431. Reconstruction of the face from the skull of an unknown person has now become an important aspect of forensic anthropology. In most cases however, available techniques have not been successful. The main problem seems to be that the human face is as much a result of the individual's anatomy as of the culture and personal preference. The life style of an individual can also be considered a variable affecting the facial appearance. After the positive identification of a homicide victim it was observed that the anatomical outline of the victim's photograph showed remarkable similarity with that of the reconstructed sketch. However, details such as dimples, smile and facial fatness were not predetermined. It was concluded that an identifier must be informed about the limitations of the technique before any identification is attempted from the reconstructed face.

9:30 am ANS-3 Domestic Breeding of Nonhuman Primates. THOMAS L. FERRELL, National Institutes of Health, Perrine Primate Center, University of Miami, School of Medicine, Miami, Florida 33157. A severe and long-term shortage of nonhuman primates threatens the continuation of many essential research activities. The Interagency Primate Steering Committee representing the combined interests of the Federal Goverment in the supply, use and conservation of nonhuman primates has developed a National Primate Plan. Basic goals are: To ensure the most·effective use of nonhuman primates, to sufficiently expand domestic nonhuman primate production and to ensure a stable supply and long term availability of nonhuman primates from their countries of origin. Specifics of the plan will be reviewed as they relate to techniques and specific species.

9:45 am ANS-4 Chorionic Gonadatrophin Production Patterns in Primates. MEG TAYLOR and M. YAŞAR IŞCAN, Florida Atlantic University, Boca Raton, FL. 33431. Chorionic gonadatrophin (CG) is a glycoprotein hormone produced during pregnancy by the synctiotrophoblast in primates. It is believed to function as an luteotrophic stimulus in early pregnancy although several other roles are implicated. Based on the available evidence it appears that the CG production patterns of New World monkeys are more closely related to the Great Apes and man than those of the two Old World monkey species studied, *Macaca* and *Papio*. This finding is a surprising divergence from the generally accepted phylogenetic primate pattern. It is postulated that one reason for the shortened CG pattern in *Macaca* and *Papio* may be related to differences in the placental aromatization mechanisms in these species.

10:00 am ANS-5 Sexual Behavior of Japanese and Rhesus Macaques. LINDA D. WOLFE, ELIZABETH H. PETERS AND WILLIAM R. MAPLES, Department of Anthropology, University of Florida, Gainesville,FL 32611. The many similar and dissimilar sexually dimorphic socio-sexual behaviors and traits of Japanese (*Macaca fuscata*) and rhesus (*Macaca mulatta*) monkeys are described and compared. The comparison is based on data collected by Wolfe on the free-ranging Japanese monkeys of Arashiyama and by Peters and Maples on the free-ranging rhesus monkeys of Silver Springs, Florida.

10:15 am ANS-6 Behavioral Adaptation of *Lemur catta*,Ringed-tailed Lemur,to a Sub-tropical Winter Climate. BARBARA E. ROTHSTEIN,Dade County Zoological Parks, Broward Community College, and P.EDWARD WEBB, Univ. of Miami School of Medicine, 735 Tyler St.,Hollywood, FL 33019. *Lemur catta* adjusts to environmental temperature changes by both group and individual behavioral adaptations. Cold temperatures and decreased irradiants result in group huddling (with the young held in the middle),or piling-on during the night and early morning, delayed feeding, only momentary defecation excursions, and increased length of "sun-bathing".
Our thanks to the staff and administration of the zoo for their help.

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION, The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

FRIDAY 3:00 pm John Young Museum and Planetarium, Laboratory

JOINT SPECIAL SESSION: Methods of Data Collecting in the Behavioral Sciences (cosponsored by the Biological Sciences Section)

BARBARA E. ROTHSTEIN, Dade County Zoological Parks and Broward Community College, and MICHAEL J. HANSINGER, Yale Peabody Museum, presiding

3:00 pm BEH-1 On Computer-Aided Observations of Insects. JANE BROCKMAN, University of Florida.

3:15 pm BEH-2 Telemetry in Birds and Mammals. P. EDWARD WEBB, University of Miami, Medical School.

3:30 pm BEH-3 Non-Intrusive Observations of Lemurs. BARBARA E. ROTHSTEIN, Dade County Zoological Parks and Broward Community College.

3:45 pm BEH-4 Problems in Quantifying Behavior. JUDITH BRUGAMEN, Busch Gardens.

4:00 pm BEH-5 Behavior in Monkeys and Man. CAROL LAUER, Rollins College.

4:15 pm BEH-6 Data Gathering in Human Behavior. MICHAEL J. HANSINGER, Yale Peabody Museum.

SATURDAY 8:00 am John Young Museum and Planetarium, Laboratory

SPECIAL SESSION B: Archaeology of Inland Tampa Bay

BARRY R. WHARTON, University of South Florida, presiding

8:00 am ANS-7 An Overview of the Archaeology of Inland Tampa Bay Area. JOAN DEMING AND BARRY R. WHARTON, Department of Anthropology, University of South Florida, Tampa, FL 33620. Over the last decade substantial portions of the inland Tampa Bay area have, for the first time, been archaeologically scrutinized, resulting in the formulation by several investigators of an inland zone land use model that contends that only small short-term camp sites will be present, and that Late Archaic through Deptford Period sites will be absent. A re-examination of pertinent archaeological and environmental data suggests the land use model is deficient in several respects. It is herein argued that the model is based upon oversimplified environmental characterization, inadequate site detection methods, non-systematic site typology, and weak temporal controls. Both existing and new data indicates a more intensive, and more-or-less continual occupation of this poorly-known region than previously hypothesized, as evidenced by the presence of large platform mounds, burial and other sand mounds, peat bog cemeteries, habitation sites, in addition to a large number of relatively small encampment-type sites.

8:15 am ANS-8 The Bostick Temple Mound Site, Hardee County, Florida. BARRY R. WHARTON, Department of Anthropology, University of South Florida, Tampa, FL 33620. A large rectangular platform sand mound located in eastern Hardee County has been preliminarily documented. In size it is comparable to several other known temple mounds of the Tampa Bay area, measuring 92 meters long, 55 meters wide, and between 4.5 and 6.5 meters high. Other elements of the site include a large borrow pit located adjacent to the mound, at least 2 discernable habitation areas, and a now-destroyed burial mound excavated by Ripley Bullen in 1953. At least 2 additional mound sites (type unknown) are located within a few kilometers of the Bostick site. Several small test excavations and surface collections indicate that occupation at the site began during the Newnans Archaic (5,000-3,000 B.C.) and continued more-or-less into the Late Weeden Island Period (A.D. 800-1,200). Pottery types from what appear to be several periods of occupation include Norwood Plain, St. Johns Incised, a local variant of Deptford Linear Check Stamped, St. Johns Check Stamped, an untyped incised/punctated ware, Weeden Island Plain, and several other plainwares.

8:30 am ANS-9 Archaeology of the Payne Creek Drainage, Hardee County, Florida. J. RAYMOND WILLIAMS, Department of Anthropology, University of South Florida, Tampa, FL 33620. Recent survey and excavation of aboriginal sites located along the Payne Creek drainage in northwest Hardee County has produced data which contradicts the generalized land use and settlement model recently proposed for this region. Thirty aboriginal sites have been recorded, indicating a wider range of site types and occupational periods than previously suspected. Several kinds of archaeological sites are present, including burial mounds, habitation sites, non-mortuary sand mounds, and small encampment-type sites. The sites are located along or just within the creek's floodplain margin, often adjacent to upper valley slope bayheads. The sand mounds, however, are confined to the margins of a large wet prairie/marsh area along the southern portion of the creek drainage. Salvage excavations at 2 habitation sites (8Hr10 and 8Hr11) suggest a seasonal occupation by small groups, probably family units. In light of this recent influx of data a revised interpretation of land use and settlement patterning is presented for northwest Hardee County.

8:45 am BREAK

9:00 am ANS-10 The Republic Groves Site (8Hr4), Hardee County, Florida. **BARRY R. WHARTON, GEORGE R. BALLO, AND MITCHELL E. HOPE**, Department of Anthropology, University of South Florida, Tampa, FL 33620. Results of test excavations by Hope and local volunteers at a partially disturbed peat bog cemetery are preliminarily analyzed and discussed. The site is composed of an upper zone of Holocene peat muck approximately 1 meter thick at its deepest point overlying a bed of Pleistocene sandy clay. The artifact assemblage, which includes a variety of utilitarian and non-utilitarian items fashioned from bone, antler, local chert, wood, and non-local stone, indicates a Late Archaic to Transitional Period use of the site. It is estimated that 37 individuals are represented by the human skeletal remains recovered from the excavations. Due to disturbance and the likelihood of intrusive burials, mode of interment is difficult to ascertain in most cases. The greatest variety and number of grave goods were associated with infant burials. The excellent preservation of organic materials and the presence of exotic stone artifacts afford a unique insight into prehistoric sociocultural systems of this little-known region.

9:15 am ANS-11 Lithic Scatters and Site Typology: a Comparison of Two Archaic Sites in Inland Hillsborough County, Florida. **KENNETH HARDIN**, 471 Lucerne Avenue, Tampa, FL 33606. Results of the lithic analyses of the Phase II (Interstate 75) investigations at the Landfill (8Hi99) and Diamond Dairy (8Hi476) sites, both inland lithic scatters, are compared. Using Binford's generalized extractive/maintenance model for hunting-gathering economies, settlement types are explored via Streuver's argument that sites which disclose a similar content and structural patterning of archaeological remains are representatives of a single settlement type. Analysis focuses on the range of tool types, debitage types, and their respective differential frequencies. Although many morphological tool class frequencies conform for the 2 sites, debitage class frequencies significantly diverge. Moreover, when functional inferences derived from tool edge angles are added to the analysis, a relatively narrower range of activities can be inferred for the Landfill site. Problems relevant to the study of lithic scatter sites are discussed and suggestions for refining research methods and techniques are explored.

9:30 am ANS-12 Discussion. B. CALVIN JONES, Florida Division of Archives, and MARIAN ALMY, Archaeology Consultants, Inc.

SATURDAY 10:00 am John Young Museum and Planetarium, Laboratory

SPECIAL SESSION C: Archaeology of South Florida

M. YASAR ISCAN, Florida Atlantic University, presiding

10:00 am ANS-13 Highland Beach Mound (8PB11). MARLENE G. LEVY, Department of Anthropology, Florida Atlantic University, Boca Raton, FL. 33431. This paper is a preliminary report and description of the various artifacts excavated from the largest known burial site in southeast Florida during the summer of 1980. While Glades Plain and Belle Glade Plain potsherds were found, analysis shows a predominance of the St. Johns Check Stamped type. Although the earliest date cannot be firmly established, these St. Johns Checked Stamped sherds indicate a prehistoric occupation of this area as far back as 1000 A.D. Many animal remains of mammals, fish, snakes, shellfish, and turtle were also found associated with the skeletons. Of these, a few bones appear to have been used as tools. This report attempts to draw a tentative conclusion that these prehistoric people exploited the Atlantic Ocean and the nearby Spanish River for their primary subsistence activity and were a part of the Glades area tradition.

10:15 am ANS-14 Preliminary Analysis of Highland Beach, FL. Skeletal Remains. PATRICIA M. SHAIVITZ and M. YAŞAR IŞCAN, Department of Anthropology, Florida Atlantic University, Boca Raton, FL. 33431. Excavation of a Highland Beach site (8PB-11) produced over ninety skeletons in varying degrees of preservation. Based on the artifacts, the site is tentatively dated about 1000 A.D. Among the various pathological specimens a skull shows some typical periosteal lesions resembling syphilis. These lesions involve the frontal and the right parietal bones. The frontal bone manifests several crater-like lesions with little healing. The parietal bone shows pathological erosion. Some endocranial lesions are seen primarily on the respective parietal bone. The objective of this paper is to report the possible presence of syphilis as well as other pathologies in South Florida.

10:30 am ANS-15 *Strombus gigas* Shell Tools From Florida and the Caribbean. WILLIAM F. KEEGAN, Florida Atlantic University, Boca Raton, FL 33431. A variety of tools were constructed from the shell of the Queen Conch, *Strombus gigas*, by the prehistoric inhabitants of Florida and the Caribbean. The analysis of these tool types requires an understanding of variation caused by the morphology of the *Strombus gigas* shell. This morphology, or shell form, is the result of the animals' ontogeny. Thus, by defining morphological homologies, and their contribution to tool form, cultural variation can be determined.

10:45 am BREAK

11:00 am ANS-16 Archaeological Investigations at Two Prehistoric Cemeteries in Dade County. ROBERT S. CARR, Historic Preservation Division, 90 S.W. 8th St. Miami, FL. 33130. Salvage excavations of two prehistoric cemeteries between 1979-1980 in Southeast Florida have provided data regarding the nature of burial patterns of prehistoric Indians that inhabitated the region from the Glades I through the Early Glades II periods. The two sites are located in two different physiographic regions. One site, 8Da1082, is located along Biscayne Bay, and the other, 8Da1053, is situated within the interface of the Everglades and the Atlantic Coastal Ridge. Additional data was recovered from adjacent middens that provided information on the cultural ecology of the region.

11:15 am ANS-17 A Comparison of Shell Tool Types from Two Prehistoric Sites in Dade County, Fl. DAVID ALLERTON, LISA BURNS, MARK DUDA, and CAROLE MEISLER, Historic Preservation Division, 90 S.W. 8th Street, Miami, FL. 33130. Salvage excavations of two prehistoric sites, 8Da1053 and 8Da1082, have resulted in the recovery of a large sample of shell tools. These tools represent a variety of types and uses. Differences are noted between tool types and tool use of artifacts recovered from the habitation and cemetery areas of each site.

11:30 am ANS-18 Medals of Conquest in Calusa Florida. WILLIAM E. McGOUN, Department of Anthropology, Florida Atlantic University, Boca Raton, FL. 33431. A group of curious small objects found throughout Southwest Florida, most of Spanish manufacture and/or material but all apparently of Indian design, were analyzed with an eye toward learning more about the social and political structure of the Indians concerned in the early post-Contact period. The data seem to support the idea that the 16th Century Calusa were a conquest society, and also cast further doubt upon the utility of the Morganian societas-civitas dichotomy for classifying individual cultures.

11:45 am ANS-19 Discussion. W. J. KENNEDY, Florida Atlantic University.

SATURDAY 1:00 pm John Young Museum and Planetarium, Laboratory

SPECIAL SESSION D: MICROETHNOGRAPHY

J. JEROME SMITH, University of South Florida, presiding

1:00 pm ANS-20 Style and Status . An Ethnographic Study of Japanese Telephone Etiquette. Benjamin F. Crabtree, University of South Florida, Tampa Florida, 33617. Language style and participant status are among the significant variables in the context of conversational interaction. Ethnographic data on Japanese telephone strategies suggests that language style plays a major role in negotiating social relations in these telecommunicative settings. A functional model helps clarify the interplay of the many linguistic and cultural components that constitute a speech situation.

1:15 pm ANS-21 **Reciprocity in a Job Setting, an Ethnographic Study.** JOE S. JONES, Department of Anthropology, University of South Florida, Tampa, Florida, 33620. Interviews with an informant, who is a waitress in a large restaurant, reveal that reciprocity contributes significantly to her ability to perform her duties. Interaction with managers, coworkers, and other restaurant personnel is guided by a strategy of self-interested altruism stimulated by the demands of shifting and uncertain workloads. Status ranking and role isolation characterize the setting's social organization, but these are muted by short term reciprocal sharing of the rights and duties involved.

1:30 pm ANS-22 The Garden: An Ethnographic Study Of a Family Tradition. GEORGENE FONT, Department of Anthropology, University of South Florida, Tampa, FL 33620. The purpose of this paper is to shed light upon the cultural phenomenon of "gardening." The garden under consideration is not limited to a small geographic area but consists of almost every plant, tree and shrub in the informant's yard. The interviews showed that the garden is not only an expression of a peoples' perceived relationship with the environment but also functions as an important and versatile source of meaning about family membership and interrelationships.

1:45 pm BREAK

2:00 pm ANS-23 "Goin' Fishin';" A Cultural Scene of a Southwest Florida Commercial Fisherman Based Upon Ethnographic Interviews. BRAD W. BURGER, University of South Florida, Tampa, Florida 33620. A native of Manatee County, Florida, actively engaged in commercial fishing, served as an informant for a series of taped ethnographic interviews. Analysis of this data revealed two major cultural themes: the seasonality/cyclicity of his life and the strong adversarial role played. Careful questioning revealed the informant was ignorant of the seminal role of mangroves in the detrital food webs fueling the systems by which his livelihood is gained. Further study of the informant's detailed knowledge of fish behavior may prove useful in zooarchaeological analysis of estuarine subsistence systems of earlier Florida natives.

2:15 pm ANS-24 "Weaving Is a Way of Life": An Ethnography study of Fiber Art. COSETTE D. FREEMAN, University of South Florida, Tampa, Florida 33620. Cultural themes and the shared knowledge of a small community of weavers are described. Componential analysis of the linguistic folk domains and a flow chart are used to illustrate the decision-making process and value system which perpetuate the unique character of the cultural setting. The interplay of an ancient art with modern materials, and the function of weaving in defining roles in the lives of these "anachronistic" artists are explored.

2:30 pm ANS-25 Discussion. J. JEROME SMITH, University of South Florida.

SATURDAY 3:00 pm John Young Museum and Planetarium, Laboratory

SESSION E: General Anthropology

STEPHEN J. GLUCKMAN, University of South Florida, presiding

3:00 pm ANS-26 Occupational strategies among urban migrants in lowland Bolivia. ALLYN MAC LEAN STEARMAN, Department of Sociology, University of Central Florida, Orlando, Florida, 32816. For a period of almost 25 years, highland Bolivians have been migrating to the lowlands in search of opportunity. Many of these migrants take up residence in urban centers which service outlying agricultural regions. Strategies for economic survival have had profound effects on traditional sex roles and family organization. The result is a fluid population with a high degree of matrifocality.

3:15 pm ANS-27 Efficacy and Toxicity of Traditional Bahamian Pharmacopoeias. J. SCOTT OSBORNE, Dept. of Anthropology, Michigan State U., E. Lansing, MI 48823 AND M. YAŞAR IŞCAN, Dept. of Anthropology, Florida Atlantic U., Boca Raton, FL 33431. Investigation of herbal remedies in traditional Bahamian pharmacopoeias frequently reveals a pharmacological basis for indigenous expectations and experiences of efficacy. However, two phenomena complicate the issue: some medicinal plants contain toxic compounds, yet indigenous residents report no negative effects from herbal remedy consumption. The potential role of traditional practitioners' procedures in eliminating such toxins is investigated through analysis of remedy preparation processes for a medicinal plant with documented toxicity (Portulaca oleracea L., containing unusual amounts of oxalic acid salts). Results indicate the natural-state plant is about 14.3%, the boiled-plant about 4.5%, and the decoction about 0.5% anhydrous oxalic acid. These findings suggest that traditional preparatory procedures may regulate medicament toxicity and that preparations of remedies' ingredients should be considered in efficacy assessments of non-western pharmacopoeias.

3:30 pm ANS-28 Preliminary Results of Salvage Excavations at the Briarwoods Site, Pasco County, Florida. JEFFREY M. MITCHEM, Department of Anthropology, University of Florida, Gainesville, FL 32611. While the author was a graduate student at the University of South Florida, emergency salvage excavations were conducted on a partially disturbed prehistoric burial mound in northern Pasco County. The mound, which was threatened by the construction of a subdivision, contained at least 60 poorly preserved human burials. On the basis of ceramic types present, the site appears to represent interments from the Late Weeden Island and Safety Harbor periods. Nonceramic artifacts were not temporally diagnostic. The location of the site in relation to surrounding environmental factors is examined.

3:45 pm ANS-29 An Archaeological Site Predictive Model for Marion County, Florida: Development and Implementation by a Regional Planning Agency. ANDREA K. LEVASSEUR AND JOE S. JONES, University of South Florida, Department of Anthropology, Tampa, Florida 33612. Relationships between present environmental characteristics and known archaeological site locations enables development of a predictive model for use by non-archaeologist planners. The model is derived from the locations of known sites, environmental factors, and other data, and points out areas likely to contain sites. Identification of archaeologically sensitive areas is useful in planning for resource preservation and mitigation. The Withalacoochee Regional Planning Council will use its site location predictive model along with a specific step-by-step resource assessment process, to review each proposed development project and assist the developer in avoiding archaeological resource destruction.

SATURDAY 4:00 pm John Young Museum and Planetarium, Laboratory

BUSINESS MEETING: Anthropological Sciences Section

J. JEROME SMITH, University of South Florida, presiding

ATMOSPHERIC AND OCEANOGRAPHIC SCIENCES

and

PHYSICAL SCIENCES

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

SATURDAY 9:00 am Junior Achievement Center, Room 2

HUGH E. WILLOUGHBY, NOAA, National Hurricane and Experimental Meteorology Laboratory, presiding

9:00 am AOP-1 Organization of Gulf Coastal Currents near the Pinellas County Headland. ERNEST D. ESTEVEZ, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. About 1000 measurements of current speed and direction were made at surface, mid-depth and bottom strata at 40 stations in a 500 sq. km area from Indian Rocks Beach to Anclote Key offshore Pinellas County, FL. A current speed of 90 cm/sec was the fastest observed. Flood tide currents were weak, moved north and east, and were affected little by wind. Ebb tidal currents were stronger, moved south and west, and were affected by wind. Surface currents and water moved west under east winds; under west winds surface currents were eastbound but a nearshore accumulation of water prevented onshore water movement. Winds produced strong vertical shear, to 160°. The coincidence of tidal currents with observed and predicted tidal heights was poor and depended on proximity to shore, the type of tide, and winds. Correlations of currents with the movement of dyes depended largely upon weather. Overall, the coastal waters near the headland are well mixed and influenced most by northern waters. The relevance of these data to red tides and sewage disposal is noted.

9:15 am AOP-2 Characterizing Petroleum Hydrocarbons in Drilling Fluids. DON ANNE', RICHARD PIERCE, AND BRAD WEICHERT, Dept. of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, Florida 32901. Petroleum hydrocarbons associated with spent drilling fluid, a toxic organic component, are being investigated to evaluate their potential environmental impact. Samples of spent fluid from drilling operations in the Gulf of Mexico were analyzed. The oil and grease content was found to be about 1 % of the total wet weight. Analysis of the petroleum hydrocarbons by gas chromatography showed the oil to be representative of a #2 fuel oil depleted of lower n-alkanes (less than n-C14) relative to API Reference #2 fuel oil. When drilling fluid was dispersed in seawater, most of the petroleum remained associated with the particulate fraction. This indicates that the major environmental impact would concern filter-feeding and benthic organisms. Studies to determine the partitioning of petroleum hydrocarbons from drilling fluids dispersed in seawater are in progress.

9:30 am AOP-3 Velocity Distributions of Metastable atoms from Electrical Discharges in He, Ne, Ar.* DENISE ANDERSON, ODALYS SANCHEZ, KENNETH HARDY AND JOHN SHELDON, Chemical Physics Lab., FIU, Miami, Fl 33199. An apparatus has been assembled at FIU to study reactions in electrical discharges and to provide beams of metastable atoms for collision studies. The machine consists of differentially pumped source and collision chambers. A gas discharge tube following the design of Muschlitz and coworkers[1] is operated within the source chamber. Discharge products effuse from an anode slit, are collimated into a beam, chopped and charged products are removed before the beam enters the main chamber. Here it passes through a collision cell and the metastable component is detected by an electron multiplier. The multiplier signal is processed by a unique data processing system to obtain time-of-flight velocity distributions. *Supported in part by Research Corp. [1]M.E. Gersch et al, J. Appl. Phys. 44, 5356 (1973)

9:45 am AOP-4 Peak Load Energy Conservation. PAMELA J. SCLACHTMAN AND JOHN H. PARKER, Physical Science, Florida International Univ. Miami, Fl 33199. Although energy conservation is a highly publicized and studied topic, one aspect of this issue which has been virtually ignored is peak load energy conservation. New power plants are built to accommodate expected increases in peak demand, not average consumption levels. Various conservation strategies may have a positive, neutral, or negative impact on peak demand. For example, strategies which lower base loads without lowering peak demand will have an adverse impact on utility load factors. This paper will analyze the impact on load factors of several major energy conservation techniques including (1) high efficiency air conditioners (2) precision landscaping and (3) passive solar cooling. An analysis of load management plans proposed for Florida will be discussed.

10:00 am BREAK

10:15 am AOP-5 Metals Associated with Molecular Weight Fractions of Spent Drilling Fluids. FRANK I. SASKA AND RICHARD H. PIERCE, Florida Institute of Technology, Melbourne, FL 32901. Interest has developed in the biogeochemical fate of drilling fluid components dispersed in the marine environment. One component under investigation is Ferrochromelignosulfonate (FCLS), an organometallic macromolecule. The molecular weight composition of aqueous soluble fractions of a commercially available FCLS and two whole spent drilling fluids was determined using High Performance Liquid-Gel Permeation Chromatography. The metals associated with the molecular weight fractions were quantitated by graphite furnace atomic absorption spectroscopy.

10:30 am AOP-6 Photometric Determination of Zenith Sky Brightness During Twilight. J. ALLYN SMITH and EDWIN F. STROTHER, Florida Institute of Technology, Melbourne, FL. Despite the availability of upper atmospheric data obtained from rockets and satellites, many physical parameters of the atmosphere remain far more accessible to investigation by ground based observations. Among the indirect methods of upper atmospheric research is the twilight sounding method with its detailed analysis of how twilight progresses with time. Here the term twilight refers to the entire complex of optical processes that occur in the atmosphere when the sun is near the horizon. As the setting sun's zenith angle exceeds 90°, the solar rays tangent to the earth traverse successively higher layers in the atmosphere, giving rise to a wide range of phenomena which largely determine the brightness of the twilight sky. The results of a photoelectric photometry program in East-Central Florida to monitor the zenith sky brightness as a function of time and solar zenith angle during twilight are reported.

10:45 am AOP-7 Planetary Gravitational Perturbations to the Semidiurnal Solar-Lunar Tidal Forces on the Earth's Atmosphere. J. J. PASQUA and E. F. STROTHER, Department of Physics and Space Sciences, Florida Institute of Technology, Melbourne, Florida 32901. Solar, lunar, and planetary positions and their mutual alignments relative to the earth have been analyzed to yield the total gravitational tidal force on the earth as a function of time. Periods of maximum and minimum planetary differential gravitational forces are identified as perturbations to the semidiurnal solar-lunar tidal forces acting on the earth. A brief review of the "Jupiter Effect" is presented and on the basis of the above analysis it is shown that these interactions have a negligible direct or indirect influence on the earth or its atmosphere.

SATURDAY 11:00 am Junior Achievement Center, Room 2

JOINT BUSINESS MEETING: Atmospheric and Oceanographic Sciences Section and Physical Sciences Section

HUGH E. WILLOUGHBY, NOAA, National Hurricane and Experimental Meteorology Laboratory, and JOSEPH C. HIRSCHBERG, University of Miami, presiding

BIOLOGICAL SCIENCES

FRIDAY 8:30 am John Young Museum and Planetarium, Alpha Room

SESSION A: Development and Physiology

CARL A. LUER, Mote Marine Laboratory, presiding

8:30 am BIO-1 Observations on the Dictyosome and Unmineralized Surface Scales of Coccolithophora sp.; Coccolithophorineae. ELIZABETH M. CANTRELL and DEAN R. NORRIS, Florida Institute of Technology, Department of Oceanography and Ocean Engineering, Melbourne, FL 32901. Culture number LB912-1 from the Cambridge Collection of Algae and Protozoa was used in this investigation. Bright field and phase contrast microscopy on whole mounts of living material yields limited information with respect to the dictyosome. Transmission electron micrographs reveal that each individual possesses a single large dictyosome, the activity of which is evidenced by distended cisternae and vesicle formation at the maturing face of the organelle. In some sections, vesicles containing fully formed unmineralized scales are present. At least two distinct types of unmineralized scales cover the cell surface. The morphologically simpler, rimless scales are layered beneath the heavier rimmed scales. It is postulated that the production of unmineralized scales occurs in the dictyosome.

8:45 am BIO-2 The Ultrastructure of the Spermatozoon of a Brooding Sea Cucumber. WAYNE A. ESTABROOKS, Department of Biology, Florida Institute of Technology, Melbourne, FL 32901. Synaptula hydriformis is a small, hermaphroditic, coelomic brooding holothurian. The ultrastructure of the spermatozoon was examined to determine its relationship to the mode of reproduction. Ripe gonads were prepared for T.E.M. by standard techniques. The apically located acrosome lies in a deep fossa in the spherical nucleus. The acrosomal granule has a central region of concentric lamellae, an electron dense region lining the basal hemisphere, and other basal specializations. In contrast to the single, doughnut-shaped mitochondrion found in other echinoderm sperm, several mitochondria occur basal to the nucleus. The flagellum, with a 9+2 axoneme, lies at the base of the distal centriole, 180° from the acrosome. The sperm conforms to the primitive echinoderm type and is not modified for a specialized mode of reproduction.

9:00 am BIO-3 Development of Tegmental Light and Dark Cells in the Chick's Auditory Lagena. G.M. COHEN AND R.F. OSGOOD, Florida Institute of Technology, Melbourne, FL 32901. The light and dark cells maintain endolymphatic composition by their secretory and absorptive activities. The endolymph is composed of high (K+) and low (Na+) and bathes the apical surfaces of the sensory epithelia of the inner ear. The lagenar light and dark cells develop in tandem with the hair cells and apparently begin to function together. During the 8-9th days (stages 34-35) the light and dark cells become distinguishable from the adjacent epithelium. By the 11th day (stage 37), light and dark cells have transformed the tegmental epithelium into a checkerboard mosaic. During the next ten days the dark cells develop extensive cytoplasmic processes in their basal ends and acquire their characteristic appearance before hatching, the 21st day (stage 46). Both the light and dark cells steadily increase their glycogen contents throughout development and into adulthood. Supported in part by NIH Grant 1-508-RR09032-01.

9:15 am BIO-4 Development of the Chick's Columella (Auditory Ossicle). G.M. COHEN AND W.S. HERSING, Florida Institute of Technology, Melbourne, FL 32901. The columella, the single avian auditory ossicle, serves the same function as the three mammalian ossicles. During development, it progressively transforms from a completely cartilaginous structure into bony and cartilaginous halves that remain permanently fused together. The bony half (columella) inserts into the oval window and a cartilaginous half (extracolumella) attaches to the tympanic membrane (eardrum). Both halves grow in length and girth during embryonic and fetal development and continue to grow after hatching: 0.7mm (stage 36), 1.15 (stage 40), 1.35 (stage 44), and 1.55 (31 days after hatching). In the columella, the primary center of ossification forms next to the footplate and then extends proximally into it and distally along the shaft. By the 19th day, the bone replaces the columellar cartilage, though internal remodelling and appositional growth continue. Supported in part by NIH Grant 1-508-RR09032-01.

9:30 am BREAK

9:45 am BIO-5 Isolation of Poly(A)+mRNA from Development Cotyledons of Pisum sativum and Translation in a Homologous Cell-Free System. PETER V. GELZINIS AND GARY N. WELLS, Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL 32901. Poly(A)+RNA was isolated from 5 day old castor bean endosperm and from 21-30 day old pea cotyledons. This was done by a phenol:chloroform extraction of the total RNA from these tissues followed by chromatography with oligo(dT)-cellulose. The RNA from both of these sources was then translated in an in vitro system prepared from imbibed, mature pea axes. This pea axis system is severely inhibited by Cl^- ions which must be eliminated from the translational assays and from the extraction buffer. Incorporation of radioactive amino acids by the pea axis extract supplemented with the pea poly(A)+RNA thus represents in vitro translation with a totally homologous system. Assays using castor bean poly (A)+RNA demonstrate the ability of this system to operate with a non-homologous messenger. For each type of RNA the system has been optimized with respect to K+, Mg^{+2}, and spermidine.

10:00 am BIO-6 Specific Activity of Glycogen Phosphorylase, Fructose Bisphosphatase, Fructose Diphosphate Aldolase, and Triosephosphate Isomerase in the Pyloric Caeca of Echinaster sp. (Echinodermata: Asteroidea). STEPHEN A. WATTS AND J.M. LAWRENCE, Department of Biology, University of South Florida, Tampa, FL 33620. Activities of the enzymes were measured at pH 6.8-7.4 and 25°C. The apparent specific activities (mean ± S.D., N=5) of phosphorylase, fructose bisphosphatase, and aldolase were .0195 ± .0063, 0.0154 ±0.0052, and 0.0668 ±0.0275 uM/mg protein/min, respectively. The low level of glycogen in the pyloric caeca and the low activity of phosphorylase, fructose bisphosphatase and aldolase suggest that glycogen utilization is low. The apparent specific activity of isomerase, 1.8924 ±0.3950 uM/mg protein/min, was higher than those of the other enzymes.

10:15 am BIO-7 Apotryptophanase Synthesis in a Vitamin B_6 Auxotroph Starved for Pyridoxine. ROSEANN S. WHITE AND JAMES NORMAN, University of Central Florida, Orlando, FL 32816. Optimal conditions were determined for induction of the apotryptophanase enzyme in Escherichia coli WG 15, a pyridoxine requiring auxotroph. Maximal induction of apotryptophanase in a glucose minimal medium supplemented with pyridoxal occurred at tryptophane concentrations between 5×10^{-4}M and 1×10^{-3}M. The WG 15 auxotroph induced for apotryptophanase but starved for pyridoxal had an approximately 10 fold lower specific activity than the auxotroph induced for apotryptophanase in the presence of 10^{-7}M pyridoxal. Preincubation of extracts with pyridoxal prior to assay showed no stimulation of enzyme activity. Possible differences in apoenzyme stability in the presence and absence of coenzyme or differences in the rate of release of catabolite repression must be eliminated before the role of coenzyme in regulation of apoenzyme synthesis is confirmed.

10:30 am BIO-8 Water Flux Across a Single Plant Cell Membrane as a Function of Temperature. JEAN PAUL LASSALLES AND A. THORHAUG, Biology Department, Florida International University, Miami, FL 33199. In the model proposed by Bisson and Gutknecht (1980) for osmotic regulation in algae, the key factor is the assymetry of the system Plasmalemma/cytoplasm/tonoplasm. We studied the water flux J_v as a function of osmotic pressure and temperature (temperature causes important membrane effects in the alga Valonia (Thorhaug, 1974)). The giant single cell marine alga Valonia is immersed and by the use of two different heat sources, the rate of temperature change in the cell is controlled. Perfusion of the cell enables us to change vacuolar osmotic pressure. Measurements of water flux at 20°C with sucrose in external solution show a very strong increase of water flux J_v with concentration: from $J_v=1.26 \times 10^{-6}$cm s^{-1} for .5M sucrose to $J_v=2.48 \times 10^{-6}$cm s^{-1} for .75M sucrose. These water fluxes are about fifty times greater for the isolated cell wall plus unstirred layer. Dr. Lassalles was supported by a grant from NATO.

10:45 am BIO-9 The Use of a Fluorescamine Technique to Measure Gulf Coast Shrimp Quality Changes. RICARDO J. ALVAREZ, Department of Food Science and Human Nutrition, University of Florida, Gainesville, FL 32611. A fluorescamine fluorescent technique for assessing quality changes in Penaeus shrimp during storage for 16 days at 5°C was compared to Total Volatile Nitrogen/Amino Acid Nitrogen (TVN/AA-N) ratio, Trimethyl Amine-Nitrogen (TMN), percent Total Extractable Protein (%TEP), pH and Aerobic Plate Counts (APC, 20°C/5 days). Fluorescamine analysis was conducted on 7.0% trichloroacetic acid (TCA) shrimp filtrates adjusted to pH 8.0. Fluorescamine data were positively correlated ($p<0.05$) with percent TEP data. Preliminary results show that the fluorescamine fluorescent technique has advantages over traditional methods in terms of simplicity and rapidity while being comparable to traditional techniques in assessing changes in shrimp quality.

FRIDAY 11:00 am John Young Museum and Planetarium, Beta Room

BUSINESS MEETING: Biological Sciences Section

ERNEST D. ESTEVEZ, Mote Marine Laboratory, presiding

FRIDAY 8:15 am John Young Museum and Planetarium, Beta Room

SESSION B: Marine Biology I

JOHN M. LAWRENCE, University of South Florida, presiding

8:15 am BIO-10 Mycostasis of Fungal Spores in Sea Foam and Marine Sediments. D. TeSTRAKE WAGNER-MERNER AND MARK HALVORSON, Department of Biology, AND DEAN F. MARTIN, CHEMS Center, Department of Chemistry, University of South Florida, Tampa, FL 33620. Mycostasis of fungal spore germination from sea foam and marine sediments in the Tampa Bay area is reported. From limited observations it appears that fungal spores from sea foam more readily germinate after a period of dehydration than spores stored in liquified foam. These observations are compared with the mycostatic effect on spore germination noted from other intertidal marine sediments in Florida.

8:30 am BIO-11 Intertidal Foraminifera of Rocky Shores. DON C. STEINKER, Department of Geology, Bowling Green State University, Bowling Green, OH 43403. Foraminiferal faunas are analyzed from the littoral zone of rocky shores. Along the central California coast foraminifers live on hydroids and bryozoans low in the intertidal. On the west coast of Florida they live among algae and show indistinct zonation. A distinct zonation of algae and associated foraminifera occurs on rock faces at Bermuda, where wave exposure influences the limits of zones and species diversity. Biotic interactions and abiotic factors such as tidal exposure, turbulence, temperature, shelter and food determine zonation patterns. Stress-tolerant species dominate. Whereas boundaries between algal populations may be sharply delimited, those between foraminiferal populations tend to be gradational. Tests display adaptations against transport, and species exhibit physiological adaptations for survival. Reproductive strategies include gamontogamy and apogamy. Intertidal populations are less abundant in more tropical areas.

8:45 am BIO-12 Foraminifera of a Meiobenthic Community in Cockroach Bay, Florida. GARY L. PATTON AND SUSAN S. BELL, University of South Florida, Tampa, FL 33620. A survey of meiofauna from Cockroach Bay, near Tampa Bay, Florida revealed that foraminifera were the second most abundant taxa in mangrove and seagrass systems. Typical foram densities for July 1980 in the mangrove and seagrass sites averaged 220 and 200 per $10cm^2$, respectively. Trochammina laevigata and Ammobaculites exilis were the dominant species found. Assemblages were unique in each system. Foram abundance was not correlated with median grain size, sorting, sediment organic content or root volume. Preliminary studies to determine the effects of structure on foram density revealed that structure has little or no effect on abundance or species composition.

9:00 am BIO-13 An Investigation of Meiofaunal Influence on Sediment Bacteria. RICKEY D. MILTON, Department of Biology, University of South Florida, Tampa, FL 33620. Effects of marine nematodes (*Diplolaimella shiewoodi*) on sediment bacteria were studied under laboratory conditions. Frozen and thawed sediments were innoculated with cultured *Diplolaimella*, and bacteria populations were enumerated by AODC methods. Results indicate that the presence of the nematodes has no significant effect on sediment bacterial populations. The implications of these results will be discussed.

9:15 am BIO-14 Comparison of Sublethal and Lethal Effects of Temperature, Salinity, and Light on Finger Coral (*Porites* spp.) from the Florida Keys and Hawaii. JEFFERY H. MARCUS AND A. THORHAUG, Department of Biology, Florida International University, Miami, FL 33199. *Porites* spp. were placed in 19ℓ aquaria in the laboratory and were exposed to a range of temperatures (10° to 34°C), salinity (5 to 45 o/oo) and light (10 to 2000μEm^{-2} sec^{-1}) regimes. Lethal and sublethal effects included varying degrees of mucus covering the expulsion of the 200 xanthellae. Particular emphasis was aimed at the duration of sublethal effects, i.e., time vs. rate of pigmentation loss and mucus development in the Pacific and Atlantic/Caribbean *Porites* spp. This study was part of a U.S. Department of Energy grant, EV-10049-A002, to investigate the effects of energy pollution on nearshore tropical/subtropical ecosystems.

9:30 am BREAK

9:45 am BIO-15 Mating Preference in the Marine Rotifer *Brachionus plicatilis*. CRAIG A. HAWKINSON AND T. SNELL, Division of Science, University of Tampa, Tampa, FL 33606. Mating preference in the marine rotifer *Brachionus plicatilis* was investigated by examining male discrimination of females from their own and different populations. These populations were collected from temporally, spatially and geographically separated regions. Populations that were collected from the same estuarine bay were temporally isolated and showed no significant mating preferences. However, among the spatially and geographically isolated populations, significant male mating preferences were observed. These preferences were asymmetrical in form, that is, the magnitude of male mating preference was not similar in reciprocal tests. The relationship of these data to rotifer population structure and the direction of evolution will be discussed.

10:00 am BIO-16 The Effects of Green and Blue-green Algae Diets on the Reproductive Rate of the Marine Rotifer *Brachionus plicatilis*. RONALD FUERST AND C. BIEBERICH, Division of Science, University of Tampa, Tampa, FL 33606. The effect of various algal diets on the reproductive rate of the marine rotifer *Brachionus plicatilis* was investigated. This rotifer is economically important to marine aquaculture as a first food source for larval fish. As a unialgal diet, *Chlorella* produced a higher rotifer reproductive rate than either *Dunaliella* or *Oscillatoria*. A combined diet of *Chlorella* and *Ocillatoria* resulted in a significantly higher rotifer reproductive rate than any unialgal diet. A combined diet of *Chlorella* and *Dunaliella* produced no such enhancement of rotifer reproductive rate. Further investigation of the *Oscillatoria* enhancing factor suggests that it is released into the medium and that ingestion by rotifers is not necessary for its action.

10:15 am BIO-17 The Frequency of Regeneration in an Interisland Reef Flat Population of *Holothuria atra* (Echinodermata: Holothuroidea) at Enewetak Atoll, Marshall Islands. J.M. LAWRENCE, Department of Biology, University of South Florida, Tampa, FL 33620. Ten percent of the individuals of *H. atra* censused on the interisland reef flat between Porky and Enewetak Island were regenerating. All regenerating individuals were less than 9cm in length. Twenty-five percent of all individuals less than 9cm in length were regenerating. There were no correlations between the mean body length, the percentage of regenerating individuals in a quadrat, or the percentage of quadrats having regenerating individuals with the number of *H. atra*/m^2 or the position of the quadrat on the reef flat. Asexual reproduction seems to make an important contribution to the maintenance of the population.

10:30 am BIO-18 Feeding Preferences of Luidia clathrata Say (Echinodermata: Asteroidea) for Plant and Animal Prey Models. T.S. KLINGER, J.B. MCCLINTOCK, AND J.M. LAWRENCE, Department of Biology, University of South Florida, Tampa, FL 33620. When offered paired choices between plaster of Paris models containing either an extract of an angiosperm (Thalassia testudinum), an alga (Gracilaria verrucosa), or a mollusk (Donax variabilis) tissue, L. clathrata showed a hierarchy of preferences. Models containing D. variabilis were significantly preferred to those containing either T. testudinum or G. verrucosa. T. testudinum was significantly preferred to G. verrucosa. Models of G. verrucosa were not accepted as a food item. The graded levels of response to a variety of prey choices and receptiveness to a plant food suggests the breadth of feeding behavior in L. clathrata may have been underestimated.

10:45 am BIO-19 Feeding Preferences of Echinoids for Plant and Animal Foods. J.B. MCCLINTOCK, T.S. KLINGER AND J.M. LAWRENCE, Department of Biology, University of South Florida, Tampa, FL 33620. The echinoids, Echinometra lucunter, Lytechinus variegatus, and Eucidaris tribuloides showed a feeding response for prey models prepared with animal food (the bivalve, Donax variabilis) as great or greater than that for prey models prepared with plant food (the seagrass, Thalassia testudinum). Preference was significantly higher for E. tribuloides offered animal models as opposed to plant models. The feeding response of L. variegatus was strong and as great for animal models as for plant models. The feeding response of E. lucunter was very weak, but as great for animal as for plant models. These results indicate that although plant foods may be the predominant type of food ingested by echinoids, preference for animal food is high. This cannot be ignored when considering the evolutionary basis for food preference in echinoids.

FRIDAY 11:00 am John Young Museum and Planetarium, Beta Room

BUSINESS MEETING: Biological Sciences Section

ERNEST D. ESTEVEZ, Mote Marine Laboratory, presiding

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

FRIDAY 3:00 pm John Young Museum and Planetarium, Beta Room

SESSION C: Plant Ecology and Evolution

RICHARD P. WUNDERLIN, University of South Florida, presiding

3:00 pm BIO-20 Plants as Indicators of Recent and Long Term Water Levels in a Central Florida Floodplain. SUSAN J. DUBOIS AND CHARLES M. COURTNEY, Applied Environmental Services, 990 North Barfield Drive, Marco Island, FL 33937. The waterward limits of certain plant species and features of individual trees, useful as indicators of high water levels around lakes, may also indicate water regimes in creek floodplains. We compared elevations of several features with observed and predicted (by hydrologic flood models) water levels near Tampa. Water stains on bald cypresses and the lower limit of "moss" and lichen growth on tree trunks indicated recent maximum water levels. The waterward edge of saw palmetto and the exposed roots of cabbage palms were $\leq .6$m below and $\leq .2$m above the predicted mean annual flood, respectively. The heights of the buttressed bases of cypresses exceeded predicted mean annual flood levels and were correlated with the diameters of the trees.

3:15 pm BIO-21 Genetic Differentiation Among Subspecies of the Helianthus debilis Complex. RICHARD P. WAIN, Department of Biology, University of South Florida, Tampa, FL 33620. Techniques of starch gel electrophoresis were employed to estimate levels of genetic differentiation among several subspecies of the Helianthus debilis complex from Florida and Texas. Genetic divergence was computed using the normalized genetic identity index of Nei. Populations representing three levels of increasing evolutionary divergence have been examined. Local populations within each subspecies are genetically very similar. Subspecies, those populations in the initial stage of speciation, exhibit a considerable amount of allelic differentiation. Mean genetic identities among semispecies, groups of populations with nearly completed reproductive isolating mechanisms, differ very little from those between subspecies. These results will be compared to speciation processes found in other groups of organisms and possible phylogenetic relationships among the Helianthus debilis subspecies will be discussed.

3:30 pm BIO-22 Allelopathy between Florida's Scrub and Sandhill Communities. DONALD RICHARDSON AND G. BRUCE WILLIAMSON, University of South Florida, Tampa, FL 33620. Two xeromorphic communities, Scrub and Sandhill, occur contiguously on elevated sand ridges in Florida and are thought to be maintained by distinct fire cycles and substrate differences. We propose that phytotoxins from fire-retardant Scrub species accumulate in Scrub soils and preclude colonization by fire-adapted Sandhill species. Leachates from selected Scrub and Sandhill species were applied to lettuce seeds to determine inhibition of seed germination and radicle growth. Significant inhibition of seed germination was found in 6 of 11 Scrub leachates and in only 2 of 9 Sandhill leachates. Significant reduction of radical growth was found in 10 of 11 Scrub leachates and in only 1 of 9 Sandhill leachates. Thus, allelopathy may be responsible for the maintenance and integrity of two distinct communities which otherwise share the same soils.

3:45 pm BIO-23 Turkey Oak Survival Strategy in Sandhill Wildfires. G. BRUCE WILLIAMSON AND EDWIN M. BLACK, Department of Biology, University of South Florida, Tampa, FL 33620. Survival rates of turkey oak were determined after a January 1976 wildfire in a Florida sandhill. Survival of the tree crown increased with pre-fire height of the tree, from a low of 3% for trees less than 2.0m high to 58% crown survival for trees greater than 3.0m. Crown survival was twice as great in open sunlight as under longleaf pine canopy, for each turkey oak height class. Comparison to survival rates in two experimental fires showed that survival of turkey oaks greater than 3.0m may vary from 39% to 100% according to fire temperature. Over 90% of stem-killed trees exhibited resprouts from underground buds, and there were no differences in percent resprouting among height classes. Turkey oak growth exhibits a period of root development and subsequently a period of rapid stem growth in order to achieve sufficient height to avoid crown scorch during wildfires.

4:00 pm BREAK

4:15 pm BIO-24 Fire Facilitation by Longleaf Pine. EDWIN M. BLACK AND G. BRUCE WILLIAMSON, Department of Biology, University of South Florida, Tampa, FL 33620. During a three hectare experimental fire on May 8, 1979 in a Florida sandhill community, the maximum temperature increase under longleaf pine (Pinus palustris) crowns greatly exceeded temperature increases under co-dominant turkey oaks (Quercus laevis)and live oaks (Q. virginiana). Temperatures were measured at 0.5m intervals at heights from 0 to 3.0m above the forest floor. Due to an extremely dry winter preceding the fire and to maximum litter accumulation, the fire was near the greatest intensity possible in this community. The extreme temperatures under the pine trees effectively eliminate the competitively superior oaks from the vicinity of adult pines. Therefore, wildfire is presumed to be a major selective force in the maintenance of diversity in the Florida sandhill community.

4:30 pm BIO-25 Primary Production, Organic Matter Budgets, and Nutrient Retention for Slash Pine Plantations Over Time. HENRY L. GHOLZ AND DALE BAUMGARTNER, University of Florida, Gainesville, FL 32611. A chronosequence of 21 stands from 2-34 years old was established in Bradford County. Analysis of organic matter distributions showed that leaf area reached a peak at about 12 years, while aboveground wood and coarse roots peaked at 25 years, the current rotation age. Net primary production increased rapidly to 1200 g/m^2-yr at 18 years, and declined to half that by 34 years. Forest floor increased steadily through 34 years (5500 g/m^2). C:N ratios for aboveground, forest floor, and soil were very high, comparable to 400 + year old stands in the western U.S. Similar mechanisms for efficient nutrient retention after harvest in both regions are proposed.

4:45 pm BIO-26 Old Field Succession in Everglades National Park. PAMELA KRAUSS, Florida Atlantic University, Boca Raton, FL 33431. Selected abandoned farmlands in the Hole-in-the-Donut area of Everglades National Park were studied for vegetative composition, abundance and community structure. Twenty-one $100m^2$ study plots were established in fields that were abandoned between the 1940's and the early 1970's. Species richness ranged from 12 to 44 species per plot. Farmlands abandoned prior to the advent of rockplowing have greater species richness and diversity than those abandoned afterwards. Vegetation assemblages in fields never rockplowed are similar to pre-farming associations.

5:00 pm BIO-27 Floristics and Structure of some Tropical Hardwood Hammocks in Everglades National Park. I. OLMSTED, P.O. Box 279, Homestead, FL 33030. Tropical hardwood hammocks are tree islands in a matrix of pine forest, marsh or mangrove vegetation. Various hammock types have been studied in Everglades National Park and Big Cypress National Preserve. Elevational transects were surveyed to relate hammocks to the surrounding vegetation and water level. Permanent plots were established for future monitoring of species composition, reproductive structure, height and basal area measurements. Natural disturbance history was traced from aerial photography, and floristic and structural dynamics related to succession.

5:15 pm BIO-28 Vegetation along a Microtopographic Gradient in the Estuarine Zone of Everglades National Park. I. OLMSTED, P.O. Box 279, Homestead, FL 33030. The vegetation in the estuarine zone of Everglades National Park is primarily determined by hydroperiod, salinity and substrate, but is kept in a state of constant flux by catastrophic forces like hurricanes, freezing temperatures, fluctuating water regimes and sea level change. This study was carried out to determine vegetation-environment relationships along an elevation gradient ranging from mangrove swamps to tropical hardwood forest. Species composition, understory cover, reproductive and canopy structure were studied in each community along a 600 m long transect. The status of buttonwood (*Conocarpus erectus*) was especially addressed.

FRIDAY 3:00 pm John Young Museum and Planetarium, Laboratory

JOINT SPECIAL SESSION: Methods of Data Collecting in the Behavioral Sciences (cosponsored by the Anthropological Sciences Section)

BARBARA E. ROTHSTEIN, Dade County Zoological Parks and Broward Community College, and MICHAEL J. HANSINGER, Yale Peabody Museum, presiding

(NOTE: see p. 4 for schedule)

SATURDAY 9:00 am John Young Museum and Planetarium, Alpha Room

SESSION D: Microbiology and Limnology

DIANE TESTRAKE WAGNER-MERNER, University of South Florida, presiding

9:00 am BIO-29 A Media Comparison for *in vitro* Growth of Heterotrophic Aquatic Bacteria. MARISTER RUIZ, Drinking Water Research Center, Florida International University, Tamiami Campus, Miami, FL 33199. Two types of media for the growth of heterotrohpic bacteria, R-2A (D.J. Reasoner and E.E. Geldreich) and SMA (Standard Methods Agar, AWWA) were compared. Raw and treated water samples, taken over a two-year period, were plated by the pour plate method on these two media and incubated at 35°C for a period of six days. Total number of colonies were obtained and a statistical analysis of this data and its implications will be presented. R-2A and SMA are used in standard plate counts to obtain the total number of bacteria present in a sample; this may provide useful information about the quality of the water sample.

9:15 am BIO-30 Prevalence of *Aeromonas hydrophila* in Central and North-Central Florida Lakes and Possible Relationship to the Trophic State of the Lakes. RICARDO J. ALVAREZ AND G. BITTON, Departments of Food Science and Human Nutrition and Environmental Engineering Sciences, University of Florida, Gainesville, FL 32611. The distribution of *A. hydrophila* in selected natural aquatic habitats in Florida were measured using mA agar and verified using AH medium. Temperature and pH were measured simultaneously with water sample collection. The densities of *A.hydrophila* in the lakes studied ranged from 27-12,000 org/100ml and correlated well (α=0.05 level) with their trophic status. A significant correlation between *A. hydrophila* counts and the average trophic state index (TSI) values (r^2=0.85) and TSI values based on chlorophyll concentration (r^2=0.90) was observed. *A. hydrophila* levels of 0-100 org/100ml were present in ultra-oligotrophic lakes, 100-500 in oligotrophic lakes, 500-1300 in mesotrophic lakes, 1300 in eutrophic lakes and >1500 in hypertrophic lakes. Lake temperature and pH had no apparent effect on the recovery of this organism from the Florida lakes studied.

9:30 am BIO-31 Microbiological Quality of Selected North-Central Florida Recreational Waters. RICARDO J. ALVAREZ, Department of Food Science and Human Nutrition, University of Florida, Gainesville, FL 32611. The incidence of heterotrophic bacteria, fungi, total coliforms, fecal coliforms, *Serratia marcescens*, *Pseudomonas aeruginosa*, *Yersinia enterocolitica*, *Edwardsciella tarda* and *Chromobacterium violaceum* was monitored in 18 widely used recreational waters in the North-Central Florida area. Samples were obtained during the summer of 1979 and winter 1980. Temperature, pH, bacterial, fungal, total and fecal coliform counts decreased in all winter samples. However, the isolation of the selected pathogenic microorganisms increased during winter. Forty-four percent of all the recreational water sampled during the entire study contained *S. marcescens*, 50% contained *P. aeruginosa*, 56% *C. violaceum* and 11% *Y. enterocolitica*. No *E. tarda* was recovered during the entire study. The presence of high levels of total and fecal coliforms in various recreational waters and the isolation of various pathogenic microorganisms suggest a potential environmental health risk.

9:45 am BIO-32 Qualitative Algal Considerations in a Granular Activated Carbon (GAC) Ozone Pilot Plant. RAMONA G. RICE, Drinking Water Research Center, Florida International University, Tamiami Campus, Miami, FL 33199. Use of ozonation as a disinfectant for drinking water followed by trickling of the water through a granular activated carbon column is presently under consideration as an additional treatment process. Samples were collected at standard sites in a GAC/Ozone pilot plant biweekly for a four-month interval. Aliquots of 500, 1000 and 2000 ml were filtered through sterile Whatman glass fiber filters and cultured in sterile Difco basal algae medium. Aseptic techniques were followed. Raw water samples entering the pilot plant were similarly examined. Algae occurrence, distribution, and system impact are evaluated from qualitative data.

10:00 am BREAK

10:15 am BIO-33 Benthic Testacida (Sarcodina, Protozoa) from sediments of Lake Washington (Florida, U.S.A.). HAYDEE LENA-HERNANDEZ, Florida Institute of Technology, Melbourne, FL 32901. Benthic Testacida from sediments of Lake Washington were studied. The Testacida were extracted from the sediments using standard foraminiferologic techniques. The determined taxa were photographed using scanning electron microscopy. Twenty one taxa were found. The majority were cosmopolitan and the most abundant were *Difflugia pyriformis* and *Centropyxis compressa*. The Testacida guild was similar to that previously studied in other American and European lakes. However, the type and size of the species were different from those found in soil and mosses. It was observed that the Testacida shell reflects the characteristics of the environment and that they could be good biological indicators.

10:30 am BIO-34 Primary Production in the Upper St. Johns River, Florida. CHRIS BOVE AND THOMAS V. BELANGER, Department of Environmental Science and Engineering, Florida Institute of Technology, Melbourne, FL 32901. Light-dark bottle primary production measurements were made at seven sites twice a month in Lake Washington and monthly in the entire upper St. Johns River for a period of seven months in 1980. Total phosphorus, chlorophyll a, specific conductance, Secchi depth and temperature were monitored at each site for correlation with productivity rates and for use in trophic state analysis. Community productivity 24 hour diurnal measurements were made bimonthly for comparison with plankton productivity. Results indicate that planktonic production in the upper St. Johns River is relatively consistent from month to month, but very low. Community production estimates were much higher and indicate that most of the production in the upper St. Johns River is in the surrounding marsh.

10:45 am BIO-35Ecology of the St. Johns River; Composition of the Detritus in Lake Helen Blazes. IRENE AIKENS, MYRA SIMPSON AND DR. JOAN P. SCHWEBEL, Bethune-Cookman College, 640 Second Avenue, Daytona Beach, FL 32014. It is felt that the buildup of detritus, aggravated in part by the hyacinth spraying operations of the St. Johns Water Management District is putting further stress on an already overburdened ecosystem. Samples of the detritus in Lake Helen Blazes southwest of Melbourne, Florida were taken from the southern end of the lake. The floodplain of the St. Johns River in this region has been reduced to a 4.8 km wide strip because of agricultural incursion and the building of levees. The samples, which were obtained from water depths of 78-103 cm were analyzed microscopically for the presence of Eichornia crassipes , the water hyacinth. Evidence compiled from anatomical, mycological and pollen data along with the presence of related freshwater angiosperms such as hydrilla, alligator weed, Eurasian watermilfoil and water sedge, support the idea that the detritus comes in part from sheet flow from areas south of the lake.

11:00 am BREAK

11:15 am BIO-36 Algae from a Florida Sphagnum Swamp. CLINTON DAWES, JERIYN JEWETT-SMITH, ERIC LESNETT, AND SANDRA UPCHURCH, Department of Biology, University of South Florida, Tampa, FL 33620. An acid bog (pH 4.5-5.5), dominated by the moss, Sphagnum sp., occurs near the Hillsborough River and close to the University of South Florida. The algal component consists primarily of diatoms (dominated by Frustulia rhomboides and Eunotia spp.) and a variety of chrysophytes and desmids. Blue-green algae are few in number and species. The bog appears to be unique to this region of Florida and the preliminary studies indicate a definite seasonal change in dominance between diatoms and chrysophytes.

11:30 am BIO-37 Macroinvertebrate Biomass and Density in the Hillsborough River Headwaters. GEORGE M. DOORIS, Division of Science and Mathematics, St. Leo College, St. Leo, FL 33574 and P. M. DOORIS, Southwest Florida Water Management District, 5060 U.S. Highway 41 S, Brooksville, FL 33512. Macroinvertebrate populations were sampled at six stations on the Hillsborough River upstream of Crystal Springs. Biomass and density were measured for each station and correlated with (1) distance downstream of source, and (2) substrate particle size. Data indicate a positive correlation of both population parameters with the downstream order of the sampling station. The relationships of biomass and density to particle size are not so well defined and suggest the presence of complex interactions. The significance of the data with respect to overall system productivity is discussed. Further, the effects of man-induced erosional processes on stream macroinvertebrates are considered.

11:45 am BIO-38 Bioenergetics of Sauger in Watts Bar Reservoir, Tennessee. JOSEPH W. MINTON, Department of Biological Science, Florida State University, Tallahassee, FL 32306 AND DR. RICHARD B. MCLEAN, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37830. This 17-month study describes the energy budget of sauger (Stizostedion canadense) in Watts Bar Reservoir, Tennessee, in order to assess the effects of prey fluctuations on that major predator. Direct field determinations of consumption and laboratory determinations of metabolism are incorporated into the balanced energy equation of Winberg (1956) to predict the growth in energy value of sauger of two age classes. Directly measured caloric gains and predicted gains over the growing season agree with 5.0 to 13.2% for the two age classes modeled, thus verifying the model. Modeling indicated that the rapid growth of the sauger was largely the result of storing energy obtained by heavy predation upon threadfin shad (Dorosoma petenense) and gizzard shad (Dororoma cepedianum) during periods when the shad were highly vulnerable to predation, and of prey switching to species of similar caloric value.

SATURDAY 9:00 am John Young Museum and Planetarium, Beta Room

SESSION E: Fish Biology

WAYNE T. PRICE, University of Tampa, presiding

9:00 am BIO-39 Spawning Season of the Bay Anchovy, Anchoa mitchilli, (Valenciennes), in Tampa Bay, Florida Determined from Egg and Larval Surveys. T. DUANE PHILLIPS, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. Ichthyoplankton samples were collected in lower Hillsborough and upper Tampa Bays at two week intervals during 1976 and 1979. A protracted spawning period is described for the Tampa Bay anchovy population based upon the presence of eggs and early larvae from March through October during both years. Spawning began after surface water temperatures reached 20°C. Major spawning occurred during the spring and early summer months with peak egg densities observed from April through July in both 1976 and 1979. Larval densities were greatest from March through August in 1976 and from April through July in 1979. Spawning ceased by November in both years.

9:15 am BIO-40 Temporal and Areal Distribution of Scombrid Larvae in the Vicinity of Palm Beach, Florida. KAREN M. BURNS, Florida Department of Natural Resources, 100 8th Avenue SE, St. Petersburg, FL 33701. Nine species of larval and juvenile scombrids were collected by monthly plankton sampling off Palm Beach, Florida during June 1970-October 1971. Additional samples were taken off Delray Beach, Florida and Savannah, Georgia. A total of 2,673 scombrid larvae were identified. Most (43%) larvae were Thunnus atlanticus. The remainder of the samples consisted of Thunnus thynnus, Katsuwonus pelamis, Euthynnus alletteratus, Sarda sarda, Acanthocybium solanderi, Scomberomorus cavalla, Scomberomorus spp. (prob. S. regalis), and Auxis spp. Sizes ranged from 2.5 to 26.1mm SL. Seasonal availability varied among the species; for example, T. thynnus were captured exclusively in May and June whereas K. pelamis were collected throughout the year. Peak spawning occurred during spring and summer for most species. Surface temperatures at capture locations ranged from 22.5 to 30.0°C; salinities varied from 32.0 to 38.0 o/oo.

9:30 am BIO-41 Distribution and Abundance of Ichthyoplankton in Apalachicola Bay, Florida in 1974. ROBERT H. BLANCHET, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. An ichthyoplankton survey of Apalachicola Bay was conducted from November 1973 to December 1974. Larvae of 42 species of fish and 13 types of planktonic fish egg were found. The most abundant species was the bay anchovy, Anchoa mitchilli, which accounted for over 75% of the larvae and 92% of the eggs counted. Other abundant larvae included the silversides (Atherinidae), skilletfish (Gobiesox strumosus) and gobies (Gobiosoma spp.), all of which were found in samples from the warm season. Cold season samples were dominated by croaker (Micropogon undulatus), menhaden (Brevoortia patronus) and spot (Leiostomus xanthurus). Spawning seasons of the species recorded were similar to those described for other areas of the northern Gulf of Mexico. Many species were found as larvae over several months of the year. Most species with pelagic eggs breed offshore; only the eggs of the bay anchovy were found to be abundant in the bay.

9:45 am BIO-42 Development of Two Laboratory-reared Estuarine Gobiid Species. KEVIN M. PETERS, Florida Department of Natural Resources, 100 8th Avenue SE, St. Petersburg, FL 33701. Eggs, larvae, and juveniles of the frillfin goby, Bathygobius soporator, and the clown goby Microgobius gulosus are described, figured, and compared. Eggs of M. gulosus are oval in shape and larger in volume than the club-shaped B. soporator eggs. Microgobius gulosus larvae are also larger than B.

soporator larvae at hatching (3.2mm SL vs. 2.0mm SL) and at other comparable developmental stages even though both settle from the water column at about 30 days. Notochord flexion as well as fin formation occur at an earlier age but larger size in M. gulosus. Bathygobius soporator adults, however, grow to a larger total size and produce more eggs/female than M. gulosus, suggesting that the small eggs and larvae of B. soporator may result from a difference in reproductive strategy.

10:00 am BREAK

10:15 am BIO-43 Feeding Habits of Two Sympatric Species of Filefish (Pisces: Balistidae) Occupying Seagrass Beds in Apalachee Bay, Florida. WILLIAM H. CLEMENTS AND R.J. LIVINGSTON, Department of Biological Science, Florida State University, Tallahassee, FL 32306. Analysis of stomach contents of Monacanthus ciliatus and M. hispidus revealed ontogenetic, spatial and temporal variability in feeding habits. Smaller individuals (21-30 mm) fed primarily on harpacticoid and calanoid copepods. As the fish grew, the contribution of plant material to the diet steadily increased. Larger fish also fed on gammarid amphipods and serpulid polychaetes. The diet of fish collected from heavily vegetated areas differed from the diet of fish from stations with less macrophyte biomass, suggesting a difference in prey availability between the two areas. The diet of each species was similar in terms of the major taxa. However, it is doubtful that this observed overlap in feeding habits is indicative of biological interactions owing to the non-overlapping seasonal peaks in abundance of each species, the density of available prey, and different patterns of species-specific predation.

10:30 am BIO-44 The Feeding Ecology of Gerreid Fishes. MARK S. PETERSON AND TERRELL W. ROBERTS, Florida Institute of Technology, Box 1150, Melbourne, FL 32901, AND R. GRANT GILMORE, Harbor Branch Foundation, Rt. 1, Box 196, Ft. Pierce, FL 33450. The feeding habits of 5 species of gerreids from the Indian River lagoon were examined over a 6 month period. Two ecologically distinct habitats were chosen: a mixed seagrass bed and an inlet channel beach, both located near Sebastian Inlet, Florida. The silver jenny Eucinostomus gula, spotfin mojarra E. melanopterus utilize inlet resources. The two groups are principally allopatric in distribution, with the seagrass species feeding mostly on calanoid copepods and polychaetes and the inlet species feeding primarily on bivalves and amphipods. Interspecific, intraspecific, seasonal, and diel variations in feeding were examined.

10:45 am BIO-45 Diurnal Variation in Visually Estimated Population Densities of Coral Reef Fishes. WILLIAM ALEVIZON AND DOUGLAS COLTON, Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL 32901. Bahamian coral reef fishes were visually censused along a 100x4 m transect at four times of day: 0900, 1200, 1500, and 1800 hours. One sample per day was obtained at each time period over a span of 20 consecutive days. Of the 42 species recorded in these samples, 25 occurred frequently enought to permit statistical analysis of diurnal variation in abundance. Nearly one fourth of these (6 species) displayed significant differences in their abundance patterns among the four time periods. It is therefore suggested that repetitive visual sampling of coral reef fishes be carried out at about the same time of day to minimize bias, which might otherwise be introduced.

11:00 am BIO-46 Impingement of Fishes and Invertebrates at a Power Plant on Tampa Bay, Florida. GARY S. COMP, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. A total of 3087 fishes (51 species) and 4710 invertebrates (19 species) were collected on the traveling screens of one unit at the Big Bend Power Station during 576 hours of sampling. Samples were collected four times per day, once every two weeks between March 13, 1979 and February 12, 1980. Most of the animals (70.8% of the fishes and 62.0% of the invertebrates) were impinged between 1800 and 0600 hours. Impingement rates varied from 3.5 to 32 animals hr^{-1} through the year and correlated with seasonal changes in the relative abundance of animals within the sampling area. This study was funded by the Tampa Electric Company and administered by Stone and Webster Engineering Corp.

11:15 am BIO-47 Cold Smoked Fish Fillets: A New Route for Florida Fish? RICARDO J. ALVAREZ, Department of Food Science and Human Nutrition, University of Florida, Gainesville, FL 32611. The objective of this work was to develop a new product form which could expand the use of traditional and underutilized Florida fish. The product is skinless and boneless fish fillet which has been flavored by a low temperature smoking (LTS) process. The LTS process requires less heat energy for production and provides a greater product yield than the traditional hot smoking process. Effects of brine concentration (0-6%), intensity of smoking (1.5 or 3.0 hr), method of cooking (baked, boiled or fried) and frozen storage on the acceptance of cold smoked mullet fillets were determined. A sensory panel indicated that fillets soaked in 4% brine for 30 min, smoked for 1.5 hr at 120°F and deep fat fried were an acceptable product. Frozen storage of the smoked fillets for two weeks or of the whole fish for six weeks prior to smoking had no significant effect on acceptance of the product. Panel members gave the product a "very good" rating and indicated they would purchase it if available.

SATURDAY 9:30 am John Young Museum and Planetarium, hallway

POSTER SESSION F

(NOTE: the following poster presentations will be on display from 9:30 am to 3:00 pm)

9:30 am BIO-48 Fish Populations in the Vicinity of the Big Bend Power Plant, Tampa Bay, Florida. BRANDT HENNINGSEN, Department of Biology, University of South Florida, Tampa, FL 33620.

9:30 am BIO-49 A Species-Area Study of a Marine Fouling Community. WILLIAM E. BROS, Department of Biology, University of South Florida, Tampa, FL 33620.

9:30 am BIO-50 Infaunal Patchiness: Relationship to Disturbance, Colonization, and Community Structure. C. E. PROFFITT, D. J. DELVIN, AND J. L. SIMON, Department of Biology, University of South Florida, Tampa, FL 33620.

9:30 am BIO-51 The Building of a Marine Education Facility. SUSAN D. HOLDERMAN, Mote Marine Science Center, 1600 City Island Park, Sarasota, FL 33577.

SATURDAY 1:30 pm John Young Museum and Planetarium, Beta Room

SESSION G: Marine Biology II

JOSEPH L. SIMON, University of South Florida, presiding

1:30 pm BIO-52 The Seasonal Cycle of Phytoplankton Populations in the Lower St. Johns River. CAROLE L. DEMORT, Department of Natural Sciences, University of North Florida, Jacksonville, FL 32216. Monthly plankton collections were made at seven sites along the lower 42 kilometers of the St. Johns River for a two year period. All of the stations exhibited major peaks in June and secondary peaks in December or January. The total number of distinct peaks decreased from four close to the mouth to two at the upper stations. Species diversity also decreased with distance from the mouth. Chlorophyll concentrations correlated closely with cell numbers. Population density appeared to be most closely correlated with salinity, phosphate concentration, and pH. This study is part of a three-year research program supported by Florida SUS Sea Grant number R-EM/6.

1:45 pm BIO-53 Observations of the Nearshore Phytoplankton Community of Northern Pinellas County, Florida. KENNETH S. CARACCIA, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. Phytoplankton investigations were conducted from Largo to Anclote Anchorage in May 1980 and October 1980. The phytoplankton community is described on the basis of 84 preserved samples and chlorophyll 'a' analyses taken at 21 stations. A total of 94 taxa were recorded. Small phytoflagellates constituted the most abundant plankton group and accounted for 52.7% of total phytoplankton numbers. Diatoms were the second most abundant group. Phytoplankton density and chlorophyll 'a' concentrations decreased in an offshore direction. Inshore stations reflected a typical estuarine-coastal assemblage of moderate diversity while stations farther from shore were characterized by more oceanic species and moderate diversities.

2:00 pm BIO-54 Benthic Soft Bottom Macro-Infauna of the Nearshore Gulf of Mexico off Pinellas Co., Florida. JAMES K. CULTER, SELVAKUMARAN MAHADEVAN, ROBERT E. YARBROUGH AND MARK L. GALLO, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. Twenty-one subtidal benthic stations were quantitatively sampled. This was the first large scale quantitative study of the shallow water continental shelf on the west coast of Florida. Findings revealed an extremely high faunal diversity probably due to a high level of substrata heterogeneity. A total of 538 different taxa were identified from 31,107 organisms collected during May and October, 1980. Various community parameters such as faunal density, species richness, diversity and equitability were described. Faunal similarity analyses (Morisita, 1959) indicated a high degree of spatial and seasonal variation. Faunal densities ranged from 1,277 organisms/m^2 to 24,321 organisms/m^2. Species counts ranged from 19 to 156 species per station.

2:15 pm BIO-55 Spatial Distribution and Bioturbation Rates of Two Echinoderms in a Sand Patch Habitat. ROBERT SCHEIBLING, Biology Department, University of South Florida, Tampa, FL 33620. *Oreaster reticulatus* (Asteroidea) and *Meoma ventricosa* (Echinoidea) were the dominant macrofauna of a 30,500 m^2 subtidal sand patch amid seagrass beds off St. Croix, U.S. Virgin Islands. *O. reticulatus* occurred throughout the patch at an average density of 0.14 individuals m^{-2}, while *M. ventricosa* was restricted to one end and averaged 0.21 individuals m^{-2}. Local densities of *O. reticulatus* and *M. ventricosa* were inversely related. Both species were deposit-feeders and competed for particulate organic matter in surface sediments. Both formed large, migratory feeding aggregations. Aggregations of *M. ventricosa* excluded *O. reticulatus* from large areas of the sand patch. The population of *O. reticulatus* ingested 3.5 m^3 sand d^{-1} and disturbed 4,506 m^2 d^{-1}. The population of *M. ventricosa* ingested 1.3 m^3 sand d^{-1} and disturbed 461 m^2 d^{-1}. The combined activity of both echinoderms would completely disturb an area equal to that of the sand patch in 6.1 d.

2:30 pm BIO-56 An Evaluation of Artifacts Associated With Predator Exclusion in the Apalachicola Bay Estuary. BRUCE M.S. MAHONEY AND R.J. LIVINGSTON, Department of Biological Science, Florida State University, Tallahassee, FL 32306. A one year study was conducted to develop a predator exclusion cage which produced minimal artifacts. Topless cages (2.5m x 2.5m) were constructed at three shallow subtidal stations. Predators were excluded for relatively short periods (2 months) to minimize fouling potential. Numerous physico-chemical variables (temperature, salinity, dissolved oxygen, pH, color and turbidity) were monitored monthly within cages and adjacent uncaged control areas. Currents and sediment changes were analyzed by gravimetric comparisons of seston settling into sediment traps and granulometric analyses of monthly sediment samples. Galvanized hardware cloth (6mm openings) caused major changes in sediment characteristics. Caging artifacts were greatly reduced when galvanized mesh was replaced with plastic netting (6mm openings). It is strongly urged that preliminary studies, with an emphasis on detection of artifacts, be conducted prior to intensive faunal sampling.

2:45 pm BREAK

3:00 pm BIO-57 The Effects of Macrofaunal Distributions on Sampling Methods in Seagrass Meadows. F. GRAHAM LEWIS AND ALLAN W. STONER, Department of Biological Science, Florida State University, Tallahassee, FL 32306. A comparative study of different sized macrofaunal core samplers (5.5, 7.6 and 10.5 cm diameters) in a shallow seagrass meadow in Apalachee Bay (north Florida) revealed significantly greater numbers of individuals collected with the small corer. No differences in species number were recorded although differences in species composition were noted with the larger devices underestimating epifaunal densities. The small corer's effectiveness was attributed to the spacing of seagrass shoots and the increased chance of sampling a shoot with the greater number of small cores taken. Subsequent microhabitat examination confirmed many of the species undersampled with the larger corers were closely associated with the seagrass shoots. Few species displayed a preference for the bare substrate between the seagrass shoots. Caution is recommended in choice of sampling methods which do not take into account the preferred microhabitats of the species under study.

3:15 pm BIO-58 A Comparison of a Variety of Remote Sampling Methods in Capturing Representative Samples of the Stone Carb (*Menippe mercenaria*). THERESA M. BERT, Yale University, Department of Biology, New Haven, CT 06520. A large scale study of the biology and population dynamics of the stone crab (*Menippe mercenaria*) has been under way since 1979. Six different prototype traps, a floating habitat, two types of trawling, and two methods of epibenthic sampling were compared with the standard plastic commercial trap to determine the most feasible method of obtaining all size classes of the stone crab for that study. Despite the biases inherent in commercial traps, they proved to be the best method of sampling for this study for a variety of reasons.

3:30 pm BIO-59 Trapping vs. Diving: A Comparison of Methods of Obtaining Ecological Information on a Decapod Crustacean. THERESA M. BERT AND JOHN M. STEVELY, Yale University, New Haven, CT 06520 and Florida Marine Advisory Program, Ag. Building, 16th St. W, Palmetto, FL 33561. The biology and population dyanmics of the stone crab (*Menippe mercenaria*) are being extensively studied in the National Park system of south Florida and in the Florida Keys, using two different methodologies. The investigation within Everglades and Biscayne National Parks uses a line of five standard commercial stone crab traps, whereas diver surveys are used in the Florida Keys. Presented here are the preliminary results of a study comparing these two sampling techniques. Results show strong biases in trapping with respect to sex ratio, size class, and abundance that may vary seasonally. Weaknesses of the common practice of employing trap data in the interpretation of the ecology of decapod crustaceans are illustrated.

3:45 pm BIO-60 Effect of Dredging on Offshore Benthic Macrofauna South of the Inlet at Fort Pierce, Florida. ROBERT O. JOHNSON, TERREL W. ROBERTS, Oceanography/Ocean Engineering Department, Florida Institute of Technology, Melbourne, FL 32901. A one year study is in progress to monitor the effects of offshore dredging on populations of benthic macrofauna. Species number, diversity and composition as well as abiotic factors such as sediment grain size, temperature, salinity, turbidity and dissolved oxygen are monitored at dredged and undredged sites for temporal changes. A clustering technique is then utilized to compare the dredged and undredged sites to determine any changes that may have occurred in the disturbed benthic community.

SATURDAY 1:30 pm John Young Museum and Planetarium, Alpha Room

SESSION H: Environmental Biology

ERNEST D. ESTEVEZ, Mote Marine Laboratory, presiding

1:30 pm BIO-61 Seagrass Mapping Project, Hillsborough County, Florida. ROY R. LEWIS, RONALD C. PHILLIPS AND RALPH LOMBARDO, Mangrove Systems, Inc., 504 South Brevard Avenue, Tampa, FL 33606. Comparison of modern (1980) and historical (1937) vertical aerial photography in conjunction with historical map analysis and ground truthing, reveal an 80% decline (6,136 ha to 1,251 ha) in the areal extent of seagrass meadows in Hillsborough County, Florida. Three general types of seagrass meadows were identified: narrow width meadows on dredged material, wide fringe meadows along natural shorelines and open bay meadows in shallow open water. Characteristics of these meadows are described. Research sponsored by the Tampa Port Authority.

1:45 pm BIO-62 An Approach to Defining Freshwater Needs of an Estuary. W.D. COURSER, SW Florida Water Management District, 5060 U.S. 41S, Brooksville, FL 33512 AND J.L. SIMON, Department of Biology, University of South Florida, Tampa, FL 33620. The increasing human need for water as Florida's population grows can impact on the freshwater needs of estuaries. Recognizing that a determination of estuarine needs is important before permitting large withdrawals from, diversion of or daming of major rivers, a four-phase program to define freshwater needs of estuaries was developed. The first two phases, a literature search and conference indicated the urgent need to define estuarine freshwater needs. For the final two phases, the Alafia River and Hillsborough Bay were hydraulically modeled and, using biological data, their requirements for freshwater determined. The authors wish to acknowledge the support on the project of scientists from the U.S. Geological Survey, Florida Sea Grant Program, U. of Miami, U. of South Florida, SWFWMD, Mote Marine Laboratory, Mangrove Systems, and Environmental Quality Laboratory.

2:00 pm BIO-63 Vegetational Changes Resulting from Underground Pumping at Large Municipal and County Wellfields in Hillsborough, Pinellas and Pasco Counties, FL. THEODORE F. ROCHOW, Southwest Florida Water Management District, 5060 U.S. Highway 41S, Brooksville, FL 33512. For more than five years biologists at the Southwest Florida Water Management District have been monitoring the vegetation and surface water levels at several large municipal and county wellfields. The vegetation of many marshes and cypress heads has changes considerably as surface waters have declined. Dog Fennel (*Eupatorium* sp.), Broomsedge (*Andropogon virginicus*) and other species with terrestrial affinities have invaded previously wet areas. The vegetational changes are discussed in relation to the amount of wellfield pumping, yearly precipitation and site-specific geological and hydrological conditions.

2:15 pm BIO-64 Impact of Hurricane David and Tropical Storm Fredrick on the Urban Forest of Santo Domingo, Dominican Republic. R.W. WORKMAN, Missimer and Associates, 1031 Cape Coral Parkway, Cape Coral, FL 33904. An October 1979 review of urban park and street trees in the city of Santo Domingo revealed extensive damage from hurricane force winds. Comparison of non-native species to native species in similar locations implies that some introduced species are more subject to wind damage than native species. Natural associations of vegetation appeared to provide the greatest resistance to wind damage. Landscape design in hurricane prone areas of Florida should consider the potential impact of hurricane force winds with attention to species selection and placement in the landscape.

2:30 pm BIO-65 Vegetational Colonization of Abandoned Phosphate Strip Mines. JOHN A. GOOLSBY, Conservation Consultants, Inc., P. O. Box 35, Palmetto, FL 33561. An ecological study of 387 parcels of abandoned reclaimed phosphate land (approximately 88,000 acres) was performed for the Florida Bureau of Geology. These areas ranged from 5 to 70 years in age. Surveys included an inventory of the plant species present as well as an enumeration of tree cover, density, and basal area data from quadrats located in the forested areas. These data were correlated with distance from natural seed sources on undisturbed floodplains and with the age of the parcels. The vegetation of these areas differed substantially from that in naturally occurring communities. Exotic species were numerous.

2:45 pm BIO-66 Revegetation Techniques on Phosphate Mined Lands. ALLEN G. SHUEY, Conservation Consultants, Inc., P. O. Box 35, Palmetto, FL 33561. Most of the phosphate mined land in west central Florida is characterized by a weedy, often largely exotic flora which is in a stalled successionary state. In an attempt to accelerate succession and to establish vegetation that more closely resembles that of natural plant communities, several restoration techniques were attempted. Mulching and direct planting have been successful. The initial results are discussed with respect to wetlands vegetation primarily.

3:00 pm BREAK

3:15 pm BIO-67 Using Natural Plant Communities as Models for Landscape Design. R.W. WORKMAN, Missimer and Associates, 1031 Cape Coral Parkway, Cape Coral, FL 33904, AND N.J. BYRD, SCCF Native Plant Nursery, P. O. Drawer S, Sanibel, FL 33957. A natural plant community represents the ultimate in landscape efficiency and function. To achieve natural system benefits in the built landscape, characteristics of natural plant associations appropriate to the area to be landscaped are assessed. Species selection, physical relationships of plants, and soil conditioning are important factors that can advance the stage of succession of some native plant communities. Landscape projects modeling natural plant communities are reviewed.

3:30 pm BIO-68 Considerations for Design of an Artificial Marsh for Use in Stormwater Renovation. ANN M. REDMOND, Northwest Florida Water Management District, Rt. 1, Box 3100, Havana, FL 32333. An artificial marsh and a filtration impoundment have been designed to work in series to renovate urban stormwater entering the Megginnis Arm of Lake Jackson. The stormwater is sediment-laden with excess nutrients, heavy metals and hydrocarbons adsorbed to the clay fraction. The sediments pose the greatest problem, but dissolved pollutants contribute as well. The function of the artificial marsh is to trap the clay fraction and provide uptake for the dissolved pollutants. Discussion will encompass criteria for vegetative component selection, particularly growing season characteristics, nutrient and heavy metal uptake capacities, periphyton host suitability, hydroperiod constraints, morphology as it relates to sediment trapping tendencies and compatability to substrate.

3:45 pm BIO-69 Stocking Rate for Grass Carp to Control Hydrilla. J. A. OSBORNE, Department of Biological Sciences, University of Central Florida, P. O. Box 25000, Orlando, FL 32816. Grass carp (_Ctenopharynodon_ _idella_ Val.) were stocked into six central Florida lakes during 1979 and 1980. Biomass of hydrilla (_Hydrilla verticillata_ (L.f.) Royle) and other submersed species of vegetation were monitored throughout a two year period. Data from these lakes were used to design a simple stocking model for grass carp vs. efficacy of control of hydrilla. The stocking model is based on stocking numbers of grass carp against biomass of vegetation rather than surface acreage. Data from Little Lake Barton and from UCF experimental ponds indicate that the size of fish used in stocking is important in the degree of vegetation control. A portion of the work was funded by the Florida Department of Natural Resources.

4:00 pm BIO-70 Improvement of Frost Resistance of Tropical Ornamentals by Soil Modification. EDWIN M. BLACK AND G. BRUCE WILLIAMSON, Department of Biology, University of South Florida, Tampa, FL 33620. First year seedlings of seven tropical tree species (_Peltophorum_ _pterocarpum_, _Leucana_ _leucocephala_, _Bursera simaruba_, _Sesbania_ _punicea_, _Lysiloma_ _latifiliqua_, _Delonix_ _regia_ and _Bauhinia purpurea_) were planted in soil mixtures of sand with compost, shell with compost and limerock with compost in an experimental plot in Tampa, Florida. The seedlings experienced eight nights of freezing temperatures during the winter of 1978-79. Six of the seven species exhibited no difference in frost damage among soil mixtures. _P._ _pterocarpum_ showed higher survival and less damage on the shell and limerock mixtures than on the sand mixture. Therefore, this tropical ornamental's northern limit in Florida may be explained by frost tolerance on different substrates.

4:15 pm BIO-71 Analysis of Spectral Curves of Citrus Trees in Color Film and Telespectroradiometry. GEORGE J. EDWARDS, Univ. of Fla., IFAS, Agric. Res. and Educ. Ctr., 700 Exp. Sta. Rd., Lake Alfred, FL 33850. Spectral data of telespectroradiometer (TSR) curves, aerial color infrared (ACIR) pictures and Kodachrome pictures of stressed and healthy citrus trees was reduced to a single value using a ratio equation. Linear correlation was determined for the single value vs. the visual ratings of the tree. The calculated Y value separated the trees into three groups while the visual ratings were in four groups. A normalized ratio product equation of the telespectroradiometer data yielded similar results. Dominant wavelengths were determined to see what wavelength the color shift was. The aerial color infrared film showed a shift to the lower wavelength for stressed trees. There was no shift for the TSR or the Kodachrome.

4:30 pm BIO-72 Migration of the Common Yellowthroat with an Emphasis on Florida. WALTER KINGSLEY TAYLOR, Department of Biological Sciences, University of Central Florida, Orlando, FL 32816. Data obtained from 3,420 autumn migrating Common Yellowthroats (Geothlypis trichas) were compared to those obtained from annual banding operations and from analytical accounts of nocturnal migrants killed at tall lighted structures and airport ceilometers. In Florida, the species is more common in the peninsular area than in the panhandle region. Adults outnumbered immatures; the majority of immatures probably precede most adults in migration. The sex ratio was nearly equal; however, adult males outnumbered individuals of the other age-sex classes.

ENGINEERING

FRIDAY 9:00 am Junior Achievement Center, Room 3

ALLEN R. OVERMAN, University of Florida, presiding

9:00 am ENG-1 Laser Speckle and Boundary-Integral Techniques in Experimental Mechanics. FAISSAL A. MOSLEHY, Department of Mechanical Engineering and Aerospace Sciences, University of Central Florida, Orlando, FL 32816. Laser Speckle Interferometry is used as an experimental technique to measure the surface displacement of a deformed solid. The method of recording displacement information is to photograph the surface of the body-which is illuminated by laser-in both a reference and deformed configurations. Data analysis in speckle interferometry yields a map of the surface displacement components along a specified closed contour for the region of interest. The experimental displacement values are then used as input data to numerically calculate, with a high degree of resolution, the state of stress at any desired interior point using the boundary-integral equation (BIE) method.

This coupled technique between laser speckle and the numerical BIE method proved to be an accurate and efficient procedure for solving significant engineering problems.

9:15 am ENG-2 Energy Constrained Economic Base Model. YASSER HOSNI, AND ROBERT DOERING, Department of Industrial Engineering and Management Systems, University of Central Florida, Orlando, Florida 32816. An economic base model was build on a Regional basis. The model function is to aid decision makers in evaluating the direct and indirect impacts of changes in economic/industrial activities among alternatives. The model is characterized by the fact that it reflect the regional energy resources. It considers the ripple effects that takes place as a given change in economic activity spreads through the various interrelated sectors. Furthermore the model carry the process a step further in defining the economic/industrial activity(s) that would optimize the economic output subject to the constrained resources.

The pilot model is build analytically, and the regional data are being collected for implementation.

9:30 am ENG-3 Impact of Stormwater Runoff on Lake Eola Water Quantity and Quality. TIM WALSH, HARVEY H. HARPER AND YOUSEF A. YOUSEF, Department of Civil Engineering and Environmental Sciences, University of Central Florida, Orlando, FL 32816. During 1980-1981, various components of the hydrologic budget and various water quality parameters in Lake Eola were measured. Continuous recordings of lake stage, evaporation, precipitation and seepage were made. Estimates of stormwater runoff and lake discharge were calculated. Also, nutrients, particularly nitrogen and phosphorus, were measured routinely at several stations in Lake Eola.

From the hydrologic budget and the measured nutrient concentrations, the impact of stormwater on lake water quality was induced. Sediment retention of the mass of these nutrient parameters was found to exceed 80 percent of the annual reported incoming runoff loadings of nutrients. It is realized that sediment uptake of nutrients will vary over time, implying an unsteady state nature of transport processes.

9:45 am ENG-4 Inactivation of Phosphorus Release from Bottom Sediments by Water Treatment Plant Sludges. D.B. JELLERSON, H.H. HARPER, AND Y.A. YOUSEF, Department of Civil Engineering and Environmental Sciences, University of Central Florida, Orlando, FL 32816. Alum-based sludge from Tampa water treatment plant were used to study their impact on anaerobic release of phosphorus from bottom sediments in Lake Eola and Lake Jessup. In situ experiments were run using nalgene chambers isolating approximately 150 liters of the water column overlying a 0.25 square meter of bottom sediments. Sludges were dosed through plastic funnels inserted inside the isolation chambers. Changes in water quality parameters with incubation time under anoxic conditions were documented and compared to similar parameters measured in control chambers and the adjacent open lake.

Alum sludge appears to significantly reduce phosphorus release from the bottom sediments of Lake Eola and Lake Jessup. The impact of alum sludge on the benthic organisms in the lake sediments is also under investigation.

10:00 am BREAK

10:15 am ENG-5 Wastewater Irrigation System for Tallahassee. A. R. OVERMAN, Agricultural Engineering Department, University of Florida, Gainesville, FL 32611. The new land treatment system for Tallahassee went on line in December, 1980. Wastewater is applied to 1,000 acres through seven center-pivot irrigation units. The irrigation rate is 3 inches per week. Grain and forage crops will be grown on a year around basis. Extensive monitoring of wastewater, crops, soil and groundwater is planned to evaluate system performance and long-term trends. Based upon previous studies, the system is expected to provide excellent crop production and wastewater renovation.

10:30 am ENG-6 Operational Problems and Controls at two Brevard County, Florida, wastewater treatment facilities. SUSAN M. MEYERS AND THOMAS V. BELANGER, Dept. of Environmental Science and Engineering, Florida Institute of Technology, Melbourne, Fl. 32901. Two wastewater treatment facilities in the south beaches area of Brevard County, Florida, were studied and compared for one year to determine the suitability of each to handle particular problems such as bulking, pinpoint floc and foaming in order to achieve a high treatment efficiency. Both plants are 2.0 MGD design capacity facilities, however one is a contact stabilization activated sludge process while the other plant is conventional activated sludge process. Statistical correlations and seasonal trends were determined between effluent SS and BOD-5 and observed parameters such as average daily flow, peak flow, MLSS, MLVSS, SVI, Sludge Age and F/M. Several preventative measures for observed problems are proposed.

10:45 am ENG-7 Analysis of Residential Irrigation. S. C. KRANC, College of Engineering, University of South Florida, Tampa, Florida 33620. Although Florida is generally considered to have adequate rainfall on an annual basis, there are many periods which are relatively dry. In order to compensate for this deficit many homeowners install sprinkler systems to compensate. Poor design and mismanagement of these systems can add substantial demand to urban water supplies. This paper examines several alternative strategies for residential irrigation which could be more economical both in the use of water and in operational costs. Design, scheduling and source of supply are considered.

FRIDAY 11:00 am Junior Achievement Center, Room 3

BUSINESS MEETING: Engineering Section

ALLEN R. OVERMAN, University of Florida, presiding

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

ENVIRONMENTAL CHEMISTRY

FRIDAY 8:00 am John Young Museum and Planetarium, The E. James Strates Room

SESSION A: General Session

HOWARD MOORE, Florida International University, presiding

8:30 am ENV-1 Removal of Trace Organic Contaminants from South Florida Underground and Drinking Waters by Activated Carbon, Synthetic Resins, and Aeration. F. M. MIDDLETON, Drinking Water Research Center, Florida International University, Tamiami Campus, Miami, FL 33199. Chlorinated and other hydrocarbons of industrial and natural origin and possible degradation products are found in underground waters and drinking waters in South Florida. Example compounds found in underground waters are tri and tetrachloroethylene, chlorinated benzenes, vinyl chloride and cis and trans 1,2-dichloroethene. Chlorinated drinking waters contain chloroform, and several other trihalomethanes owing to the reaction of chlorine added during water treatment. Possible health effects from such materials may occur and regulatory control of concentration levels is being established. Adsorption capabilities of activated carbon, and synthetic resins for these compounds have been tested over a 2-year period. Removal of volatile contaminants by aeration has been researched. Methods of conducting these studies and results are discussed. Financial support for this project was by the US EPA.

8:45 am ENV-2 Color, TOC and TTHMFP Removal by Magnesium Coagulation. CHRIS FERRARO AND JAMES S. TAYLOR, Civil Engineering and Environmental Sciences Department, University of Central Florida, Orlando, FL 32816. The magnesium process for potable water treatment utilizes magnesium which is recovered by carbonation of the sludge produced in the coagulation process. A study was initiated to determine if the recycled magnesium would increase the color, TOC or TTHMFP after treatment. Results to date indicate that the color, TOC and TTHMFP in the coagulated, settled, and filtered water increases as the amount of recycled magnesium dosed as the coagulant. Color, TOC and TTHMFP variation during coagulation were approximately 60 to 10 Pt-Co, 20 to 10 mg/l and 1800 to 800 μg/l, respectively. Optimum coagulation pH and dose was 12 and zero mg/l, respectively, which was due to the 15 mg/l Mg^{++} residual in the raw water. This work will continue to investigate a high color, low Mg^{++} water as well as the low color, high Mg^{++} water investigated.

9:00 am ENV-3 Magnesium Recovery Using Carbonation and Activated Carbon. KATHLEEN O'TOOLE GILL AND JAMES S. TAYLOR, Civil Engineering & Environmental Sciences Department, University of Central Florida, Orlando FL 32816. A study was initiated to assess the ability of granular activated carbon (GAC), Calgon F-400, to remove color from recycled magnesium by continuously pumping the recovered magnesium liquor through a bed of GAC 10.5 in. deep. Empty bed contact time varied from 7 to 10 min. The pH of the recycled magnesium liquor was adjusted to approximately 3,7 and 10 for three separate runs of each pH value. Color, TOC and TTHMFP 48 were monitored with time as the liquor was passed through the GAC filter. The resulting filtrate was utilized in a jar test to treat water taken from the portable water source. Mg++, Color, TOC and TTHMFP 48 for the recovered magnesium liquor ranged initially from 800-1600 mg/l, 3000 to 16,000 Pt-Co, 250 to 600 mg/l and 35,000 μg/l, respectively. More than 90% of the original concentrations of TOC, color and TTHMFP 48 were removed initially. However, breakthrough of all parameters through the filter began almost immediately and 50% of the TOC, TTHMFP 48 and color was observed in the filtrate after 30 to 40 hours of operation in all cases.

9:15 am ENV-4 Standard Additions Applied to the Organic Phase of an APDC-MIBK Chelation-Extraction for Flame Atomic Absorbtion Determination of Cd, Cu, Pb, and Zn. KELLIE D. DICKINSON, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. A method is presented for the rapid analysis of low levels of Cd, Cu, Pb, and Zn in aqueous samples of varied composition. After chelation-extraction with ammonium pyrrolidine dithiocarbamate (APDC) and methyl isobutyl ketone (MIBK), four point standard addition curves are prepared on aliquots of the organic phase from each sample by adding known amounts of the test metals in an organic solution. Linear regression and the X-intercept of the resultant line gives the concentration of the organic phase which is related back to the sample's original aqueous concentration. While the slopes of the individual standard addition curves are still matrix dependent, the method avoids the inaccuracies generated by the indiscriminate application of the absorbances of samples of unknown composition to a distilled water calibration curve.

9:30 am ENV-5 Chemical Characteristics of Medard Reservoir, a Former Phosphate Mining Site in Hillsborough County. P. M. DOORIS, J. A. HEBERT, AND J. M. POST, JR. Southwest Florida Water Management District, 5060 U.S. Hwy. 41 S., Brooksville, FL 33512. Medard Reservoir is exceptional in that it is a relatively new surface-water facility (312 ha) developed in a phosphate extraction site in eastern Hillsborough County. Data for the chemical characteristics of the reservoir, which has been investigated for over two years are presented. Certain chemical parameters are emphasized, particularly F, PO_4-P, N, Fe, and dissolved oxygen. The data are compared with those from natural lakes in the county as well as those from another phosphate pit lake located in Polk County, already descibed in the literature. The trophic state of the reservoir is estimated based on the methods of Carlson and Shannon and Brezonik. Loading rates for nitrogen and phosphorus are calculated and discussed in terms of the expected useful life of the reservoir. The potential for the development of other former phosphate mines for water-based recreational uses is discussed.

9:45 am BREAK

10:00 am ENV-6 Autotrophic Nitrifier Populations and Inhibition of Ammonium Oxidation in Natural and Sewage-Enriched Cypress Swamps. FORREST E. DIERBERG, Department of Environmental Science and Engineering, Florida Institute of Technology, Melbourne, FL 32901. The occurrence of autotrophic nitrifiers in the peat from the floors of a natural cypress dome, a cypress dome receiving deep artesian groundwater, and two cypress domes amended with secondary treated sewage effluent, were assessed by surveying their population densities. The absence of ammonium oxidation in the surface waters of the natural dome was due to the low pH and not to any toxic organic chemical effects present in the humic-colored water. This probably explains the low density (0-56 cells/cm^3) of autotrophic nitrifiers found associated with the peat from that dome.

10:15 am ENV-7 Frequency Distribution Patterns and Partitioning of Copper, Iron and Zinc in the Black Mullet (*Mugil cephalus*). CHARLES J. VENUTO and JOHN H. TREFRY, Dept. of Environ. Science and Dept. of Ocean. and Ocean Engr., Florida Inst. Tech., Melbourne, FL 32901. Our study examined the distribution and potential pollution of Cu, Fe and Zn in mullet from Turkey Creek, an embayment of the Indian River Estuary, Florida. Metals partition such that values (dry wt.) in decreasing order were: liver > gills > muscle. For liver tissue, Fe concentrations (2420± 1040μg/g) were higher than those for Cu (510±350μg/g) and Zn (330±140μg/g). In the gills, Fe levels (380±140μg/g) were also greater than those for Zn (96±26μg/g) and Cu (6.3±4.6μg/g). Overall, the muscle tissue metal values were much lower with Fe (19±15μg/g) greater than Zn (13±5μg/g) and Cu (1.1±1.6μg/g). These required trace elements are under homeostatic control and were expected to be normally distributed; yet, Cu in the organs investigated, and Fe and Zn in the muscle were non-normal, positively skewed. Metal concentrations generally did not covary with weight or length. Significant correlations ($P \leqq 0.05$) were observed for Cu, Fe and Zn in the gills and Fe with Cu and Zn in the liver.

10:30 am ENV-8 Use of *Chlamydomonas reinhardii* to Test Herbicide and Plant Growth Inhibitors. Mark J. Halvorson, Julio Herrera, and Dean F. Martin, Chemical and Environmental Management Services (CHEMS) Center, Department of Chemistry, University of South Florida, Tampa, FL 33620. F. D. Hess [*J. Weed Sci*, *28*, 515-520 (1980)] has described the use of *C. reinhardii* as an assay organism for testing herbicides. The present paper describes the application to the analysis of naturally occurring Hydrilla inhibitors. The advantages and limitations of the technique are considered.

10:45 am ENV-9 A Survey of Herbicide Residues Resulting from an Aquatic Weed Control Program. L.S. Friedersdorff and Dr. R.H. Pierce, Jr., Florida Institute of Technology, P.O. Box 1150, Melbourne, Florida 32901. The herbicide, 2,4-dichlorophenoxyacetic acid (2,4-D) and its degradation products (chlorophenols and chloroanisoles) were suspected of contaminating the Melbourne Tillman Drainage District-Turkey Creek system as the result of an aquatic weed control program. Water and sediment were collected from March 3, 1980 through June 30, 1980. Organic herbicides were recovered from water by adsorption resin (XAD-2, Rohm & Haas) and from sediment by homogenization in a mixture of acetonitrile: water: acetic acid (70:28:2 v/v/v). Although 833 Kg of 2,4-D was applied directly to the system during the study period, analysis by high performance liquid chromatography showed no detectable levels of 2,4-D (1.6 μg/l & 39.0 μg/kg) or the degradation products remaining in the water or sediment.

11:00 am ENV-10 Sorption Characteristics of Ethion. R. J. PFEUFFER AND F. DIERBERG, Dept. of Environmental Science and Engineering, Florida Institute of Technology, Melbourne, FL 32901. The behavior of the organophosphorous pesticide ethion (O,O,O',O', tetraethyl-S,S'-methylenebisphosphorodithioate) in sediment was studied using gas chromatography equipped with a ^{63}Ni electron capture detector. Sediments from a drainage canal adjacent to an orange grove near Fellsmere, Florida, were used to determine the adsorption and desorption isotherms of the pesticide.

11:15 am ENV-11 Determination of diquat and 2,4-D concentrations in the upper St. Johns River and their implications. ALLAN E. SCHREIBER AND THOMAS V. BELANGER, Dept. of Environmental Science and Engineering, Florida Institute of Technology, Melbourne, Fl 32901. Diquat and 2,4 dichlorophenoxyacetic acid are used as herbicides in the upper St. Johns River, a class I water that serves as the potable water source for South Brevard County, Florida. The effects of long term ingestion of these compounds, however, are not clearly understood. A method for the measurement of diquat by a simple analytical procedure is evaluated. A water sample is hydrogenated at ambient temperature and pressure followed by hexane extraction gas chromatography. 2,4-D is analyzed by esterfication followed by electron capture gas chromatography. Samples during wet and dry seasons are analyzed to determine if possible detrimental health effects exist.

FRIDAY 11:30 am John Young Museum and Planetarium, The E. James Strates Room

BUSINESS MEETING: Environmental Chemistry Section

HOWARD MOORE, Florida International University, presiding

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

FRIDAY 3:00 pm John Young Museum and Planetarium, The E. James Strates Room

SPECIAL SESSION B: Management of Undesirable Organisms by Natural Means

DEAN F. MARTIN, University of South Florida, presiding

3:00 pm ENV-12 The Current Status and Future Prospects of Managing Tomato Diseases in Florida by Natural Means. RONALD M. SONODA (1), R. A. VOLIN (2), J. M. MAROIS (3), AND D. J. MITCHELL (4), Agricultural Research Center, University of Florida, Ft. Pierce, FL 33450 (1), Agricultural Research and Education Center, University of Florida, Homestead, FL 33031 (2), Soil-Borne Diseases Laboratory, Plant Protection Institute, AR, SEA, USDA, Beltsville, MD 20705 (3), and Department of Plant Pathology, University of Florida, Gainesville, FL 32611 (4).

A survey of current methods used in Florida for managing tomato diseases without the use of pesticides is presented. Current research by the authors on managing tomato diseases by microbial antagonists, cultural practices, and host resistance is discussed. The potential for future use of natural means of managing tomato diseases is also covered.

3:15 pm ENV-13 Some Chemical Characteristics of Hydrilla Inhibiting Sediment from Lake Starvation, Hillsborough County, Florida. Robert S. Chatham and Dean F. Martin, Chemical and Environmental Management Services (CHEMS) Center, Department of Chemistry, University of South Florida, Tampa, Florida 33620. Lake Starvation, Hillsborough County, is notable for the observation that Hydrilla though present has not proliferated during the past several years. Previous studies have shown that it is possible to extract Hydrilla-inhibiting material from the sediment [Dooris and Martin, Water Resources Bull. 16, 112 (1980)]. The present study examines the variation of sediment properties with depth, including, water content, organic content, and characteristics of the extracts.

3:30 pm ENV-14 Potential Management of Ptychodiscus brevis through Selective Photodynamic Action. John Barltrop, Barbara B. Martin, and Dean F. Martin, Chemical and Environmental Management Services Center, Department of Chemistry, University of South Florida, Tampa, Florida 33620. The unarmoured dinoflagellate, Gymnodinium breve (or Ptychodiscus brevis) was used to test the effectiveness of the photodynamic action of hematoporphyrin. Four systems were compared: light control and dark control (organisms in light and dark, respectively, for 24 hours) versus dark and light test (organisms plus 8 x 10^{-5}M porphyrin in dark and light, respectively, for 24 hours). Essentially total destruction was observed for the last system (light test) and no statistically significant differences were observed among the other three systems. The effect of concentration of porphyrin was tested ($10^{-4.1}$, $10^{-5.1}$, $10^{-6.1}$, $10^{-7.1}$M) and only the lowest concentration had no discernable effect. Similar studies were conducted using a cyanobacterium Gomphosphaeria aponina; the highest concentration used $10^{-4.1}$M had no discernable effect.

3:45 pm ENV-15 Cytolysis of the Florida red tide organism Ptychodiscus brevis by redox dyes. Barbara B. Martin, Dean F. Martin, Seymour Zigman, and B. C. Antonellis, Chemical and Environmental Management Services (CHEMS) Center, Department of Chemistry, University of South Florida, Tampa, Florida 33620. Previous studies [Science, 208, 188-191 (1980)] demonstrated that a series of cyanine dyes used in photography inhibit mitosis and cell growth in sea urchin eggs, and that those dyes having reduction potentials (E_R) more negative than -1 V were inhibitors, while the dyes with more positive E_R values were not inhibitors. Two representative cyanine dyes were tested against the unarmored dinoflagellate Gymnodinium breve (Ptychodiscus brevis). The active dye caused cytolysis. The cell survival was determined as a function of time, and under the conditions used followed a zero-order kinetic pattern. In addition, cytolysis occurred to the same extent during the 24-hour test whether the dye and cells were illuminated or not, which suggests that the active dye was not acting as a sensitizer for singlet-oxygen production.

4:00 pm BREAK

4:15 pm ENV-16 Influence of Lake Sediment Extracts on Hydrilla verticillata: Summary and Status Report. P.M. DOORIS. Southwest Florida Water Mgt. Dist. 5060 U.S. Hwy. 41 S., Brooksville, Fl. 33512. and D.F. MARTIN. Center For Chemical And Environmental Management Services, U. of So. Fla. Tampa, Fl. 33620. In work done over several years, extracts made of the sediments of certain lakes have been shown to inhibit the growth of Hydrilla verticillata. The physical and chemical characteristics of the extracts have been investigated, and the inhibitory activity has been compared to that of extracts prepared from other materials of natural origin, e.g., cypress bark. Studies continue in an effort to identify the hydrilla-inhibiting material present in the lake sediment. This paper will present a status report of these long-term investigations.

4:30 pm ENV-17 An Investigation of Compounds Cytolytic Toward the Red Tide Organism, Ptychodiscus brevis (Davis) Steidinger, from Florida Marine Sediments. Ralph E. Moon, Thomas N. Krumrei, and Dean F. Martin, Chemical and Environmental Management Services (CHEMS) Center, Department of Biology and Department of Chemistry, University of South Florida, Tampa, Florida 33620. Analysis of marine sediment samples from the west coast of Florida demonstrated similar chemical and biological characteristics to the marine natural product "aponin". Chemical similarities were demonstrated using thin-layer chromatography and high-pressure liquid chromatography. Biological activity of sediment extracts was determined through cytolytic bioassays and fungicidal testing. The widespread occurrence of cytolytic agents in marine sediments will be considered.

4:45 pm ENV-18 Criteria for a Successful Red-Tide Control Agent: A Progress Report. D. F. Martin, Chemical and Environmental Management Services (CHEMS) Center, Department of Chemistry, University of South Florida, Tampa, FL 33620. It seems appropriate to review the criteria for a successful control system for the Florida red tide organism (Ptychodiscus brevis) and to determine the extent to which we can presently satisfy those criteria. Research to date indicates several promising approaches including management by indigenous organisms, and the capability for predicting red tide seems to be improving. But the larger question, perhaps, remains concerning management of red tide under selected conditions: Could we, should we, will we?

FLORIDA COMMITTEE ON RARE AND ENDANGERED PLANTS AND ANIMALS

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

FRIDAY 2:55 pm John Young Museum and Planetarium, Alpha Room

SESSION A: Plants and Lower Vertebrates

DANIEL B. WARD, University of Florida, presiding

2:55 pm REB-1 Introduction: FCREPA's Affiliation with the Florida Academy of Sciences. L. M. EHRHART, Department of Biological Sciences, University of Central Florida, Orlando, FL 32816.

3:00 pm REB-2 The Eriochloa michauxii (Poaceae: Paniceae) Complex in Florida. ROBERT B. SHAW, School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611. Eriochloa michauxii is a perennial grass found in fresh or brackish marshes and sandy prairies predominantly in central and south Florida. Two varieties other than the typical form have been described (var. longifolia and var. simpsonii). Variety simpsonii has been listed as a threatened or rare plant. Principal component analysis and analysis of variance were used to determine the amount of variation within as well as among members of the complex. Analyses indicated considerable variation in spikelet, panicle and vegetative characters within the typical variety. The only consistent differences between var. longifolia and the typical variety were vegetative; thus, var. longifolia was not accepted as a distinct taxon. However, var. simpsonii consistently differed in several spikelet and panicle characteristics to warrant retention as a distinct variety.

3:15 pm REB-3 Florida's Endangered and Threatened Coastal Dune Plants. ROBERT M. CRAIG AND DONALD C. SMITH, Soil Conservation Service, Box 1208, Gainesville, FL 36202. A detailed study of 155 coastal dune sites throughout Florida identified

10 rare and endangered plant species. Information was obtained on climatic adaptation, occurrence, dominance, location of the dunes, and plant characteristics. Propagation methods were also determined for two of these plants that have beautification and erosion control features. These plants are beach creeper (Ernodea littoralis Sw.) and sea lavender (Mallotonia gnaphalodes (L.) Britt).

3:30 pm REB-4 Ecological and Distributional Observations of Certain Tropical Peripheral Fishes in Florida. R. GRANT GILMORE, Harbor Branch Foundation, Inc. Rt 1, Box 196, Ft. Pierce, FL 33450. The tropical peripheral fishes, Oostethus brachyurus lineatus, Gobiomorus dormitor, Awaos taiasica and Gobionellus pseudofasciatus are found in coastal freshwater streams throughout much of the American tropics. These species range into Florida exclusive of extreme south Florida and the eastern Gulf of Mexico. Historically these species have been considered rare in Florida. However, recent collections made in specific stream habitats along the east central coast of Florida have produced enough specimens to discuss certain aspects of their life history. Habitat specificity and other environmental parameters effecting their distribution are discussed.

3:45 pm REB-5 Influence of Range Improvement Practices on Gopher Tortoise Burrows. GEORGE W. TANNER, School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611. In August 1980 a study was initiated to determine the efficacy of roller chopping and web plowing for saw palmetto (Serenoa repens) control and livestock forage improvement near Arcadia, Florida. Numerous gopher tortoise (Gopherus polyphemus) burrows were observed along micro-ridges within the 32.4 ha study area. These burrows were mapped and noted as being active or inactive immediately prior to site treatment. At 1, 2 and 5 mo post-treatment the burrows were monitored for signs of activity. Both treatments significantly reduced the number of active burrows. Roller chopping reduced the number of active burrows by 86%, whereas web plowing resulted in a 43% reduction. Since gopher tortoise colonies appear to be restricted to ridge-line microsites within the flatwoods range site, it is recommended that these unique microsites be excluded from mechanical range improvement practices.

4:00 pm BREAK

4:15 pm REB-6 Predation and Nest Success in Two Species of Marine Turtles (Caretta caretta and Chelonia mydas) at Merritt Island, Florida. BARBARA A. SCHROEDER, Merritt Island National Wildlife Refuge, P.O. Box 6504, Titusville, FL 32780. A total of 257 Caretta and 12 Chelonia nests were marked along a 9.65 km stretch of beach during the 1980 nesting season (May - September). Since 1978 a raccoon control program has been implemented in this area to reduce nest predation. An additional 25 Caretta nests were marked outside the raccoon removal area for a predation rate comparison. All nests were monitored for predation or emergence through November. Raccoon predation of Caretta nests within the raccoon control area was 24.5%. Predation outside the raccoon removal area was 72%. All Chelonia nests were protected by use of wire screening. Clutch size, hatching success and incubation period were determined for nests remaining after predation. This study was funded by NASA contract no. CC-90829A.

4:30 pm REB-7 Sea Turtles vs. Dredging: A Conflict with the Endangered Species Act. JONATHAN D. MOULDING, Environment and Resources, U.S. Army Corps of Engineers, P.O. Box 4970, Jacksonville, FL 32232. A manmade navigation channel at Cape Canaveral has become the adopted habitat for the largest known concentration of loggerhead turtles - a threatened species protected under the Act. During maintenance dredging of the channel in 1980 to provide access to the Navy's Trident submarine base, it was discovered that despite a major relocation effort involving 1250 loggerheads, it could not be ensured that the dredge would not take turtles - a technical violation of the Act. This resulted in a conflict that was not readily resolvable, since projected losses of individual turtles had previously been deemed by the National Marine Fisheries Service to pose no jeopardy to the continued existence of the species. Through an apparent oversight in the drafting of the amendments to the Act, there is no provision for an exemption from the prohibition of "taking" in the absence of a "jeopardy" opinion. The rescue operation and other steps taken to protect turtles will be discussed in the context of the Act.

4:45 pm REB-8 Marine Turtle Mortality on the East-Central Florida Coast in 1980. L. M. EHRHART, University of Central Florida, P.O. Box 25000, Orlando, FL 32816. The strandings of carcasses of 105 loggerhead turtles (Caretta caretta), four green turtles (Chelonia mydas) and two leatherback turtles (Dermochelys coriacea) were recorded in Brevard and Volusia Counties, Florida, in 1980. The usual annual pattern of stranding frequency, involving a peak in late fall and relatively few strandings during the rest of the year, was altered in 1980 by two factors. From 15 March through 10 June a poorly understood pathologic condition caused unusually high loggerhead mortality. The syndrome included severe emaciation and infestations of barnacles on the normally bare skin of the head, shoulders and fore-flippers. The second factor, a dredging operation at Port Canaveral, augmented the frequency of strandings in July and August. There is a persistent subequal bimodality in the size distribution of loggerhead carcasses examined. The constriction in the distribution is in the 80-90 cm range (no loggerheads in this interval were seen in 1980). Approximately 80% of the carapaces were less than 80 cm long; 20% exceeded 90 cm.

5:00 pm REB-9 Atlantic Salt Marsh Snake Survey, Merritt Island, Florida. JAMES J. HEBRARD, Univ. Nairobi, P.O. Box 30197, Nairobi, Kenya. ROBERT C. LEE, Merritt Island NWR, P.O. Box 6504, Titusville, FL 32780. During June and July of 1979 and 1980 8 localities on Merritt Island National Wildlife Refuge were surveyed for the Atlantic Salt Marsh Snake (Nerodia fasciata taeniata). On 11 nights, (26 party nights) over 80 snakes were observed and 55 were captured. Nearly all captures were in ditches inside mosquito control impoundments. Most snakes were perched in mangroves or lying at the land-water interface in dense Distichlis. Salinities at capture sites ranged from 14-35 ppt. Midbody dorsal scale rows averaged 21(19-23,n=55) and subcaudal scutes averaged 78(n=21). About half the females were gravid and the number of embryos ranged from 2 to 11. No newborns were found. The extreme variability of the color and pattern of the snakes indicate a very plastic gene pool. The influence of 5 subspecies was present and no "pure" population was found. Research funded by U.S. Fish and Wildlife Service contract no. 14-16-0004-79-81 and Kennedy Space Center contract no. CC-90829A.

SATURDAY 9:00 am John Young Museum and Planetarium, The E. James Strates Room

SESSION B: Higher Vertebrates

JAMES N. LAYNE, Archbold Biological Station, American Museum of Natural History, presiding

9:00 am REB-10 Brown Pelican and Wood Stork Nesting Survey, Merritt Island National Wildlife Refuge, Florida, 1980. LORRAINE L. BREEN, Merritt Island NWR, P.O. Box 6504, Titusville, FL 32780. Brown pelican (Pelicanus occidentalis) and wood stork (Mycteria americana) nesting success was monitored at Merritt Island NWR in 1980. Estimates of the number of nests were determined from low level 35 mm aerial photographs of each colony. Approximately 500 pairs of brown pelicans nested at one colony. Successful nests (nests that reared young) produced an average of 1.6 young per nest. Approximately 400 pairs of wood storks produced an average of 2.2 young per nesting attempt. An additional 10 pairs of wood storks nested at a newly established colony site for the second consecutive year. An estimated 900 wood stork young were fledged from these colonies. The results of this study were compared to previous nesting records. This study was funded by Kennedy Space Center under contract CC-90829A.

9:15 am REB-11 Bald Eagle Management at the Local Government Level. JEFFREY L. LINCER, County Environmental Specialist, P.O. Box 8, Sarasota, Florida 33578. Except for federally-funded or permitted projects, like an Interstate Highway, regulations promulgated by these levels of government are inadequate to protect nesting bald eagles on private property. Local government has a responsibility and a unique opportunity to help protect and manage this endangered species. A "Bald Eagle Protection Ordinance" is being developed by the author. However, conflicts between bald eagles and developer have, historically, been handled using a variety of political and biological approaches. Land management, zoning, and planning techniques which have been successful include: concentric circles of preservation and protection around nest trees; maintaining established visual corridors and hunting lanes;

early planting of "privacy" landscaping; discrete posting of "No Tresspassing" signs; restricting development activity and other disturbances during the nesting period; longterm provisions for alternative nest sites and other appropriate habitat; and engendering a sense of stewardship (if not a marketing opportunity) in the developer.

9:30 am REB-12 Habitat Preferences of the Florida Scrub Jay. DAVID R. BREININGER, Dept. of Biological Sciences, Florida Institute of Technology, Melbourne, FL 32901. Various habitat characteristics that might influence the relative abundance of the Florida Scrub Jay *Aphelocoma coerulescens coerulescens* were investigated on Merritt Island National Wildlife Refuge. The Florida Scrub Jay is a threatened species that inhabits the open oak scrub in Central Florida. Some habitat characteristics investigated include the amounts and types of open areas, insect density, acorn production, time since burning, vegetational composition, height and density. A major goal of this investigation is to define what habitat characteristics indicate optimal habitat.

9:45 am REB-13 Distribution and habitat of breeding Seaside Sparrows in Florida. HERBERT W. KALE II, Florida Audubon Society, 35-1st Ct. SW, Vero Beach, FL 32960. Six subspecies of the Seaside Sparrow (*Ammospiza maritima*) are resident in coastal marshes of Florida: Smyrna Seaside (*A. m. pelonota*), Dusky (*nigrescens*), Cape Sable (*mirabilis*), Wakulla (*juncicola*), and Louisiana (*fisheri*). Seasides no longer occur south of the St. Johns River in Duval Co., and the abundant populations north of the river are continuous with the Georgia population of *A. m. macgillivraii*, with which they are probably synonymous. The Dusky population is represented by five males now in captivity in Gainesville. The Cape Sable Seaside remains healthy in Everglades National Park. Scott's Seaside, once found south to Old Tampa Bay, occurs from New Port Richey north to the Pepperfish Keys area where it merges with the Wakulla Seaside, abundant north to Apalachee Bay area. Inexplicately, no breeding Seasides are found from Alligator Harbor west to Choctawhatchee Bay, where a small population exists near Hogtown Bayou. Two small populations of the Louisiana Seaside occur in East Bay (Santa Rosa Co.) and northeast Escambia Bay (Escambia Co.).

10:00 am BREAK

10:15 am REB-14 Conservation Biology of *Peromyscus floridanus*. I. JACK STOUT, Department of Biological Sciences, University of Central Florida, Box 25000, Orlando FL 32816. Problems in the conservation biology of *Peromyscus floridanus* are highlighted. *P. floridanus*, a Florida endemic, is largely confined to sand pine scrub habitats. Destruction, fragmentation, and isolation of these habitats pose serious threats to the continued existence of *P. floridanus* over its former range. Isolation of habitat islands, coupled with limited dispersal capabilities, may make *P. floridanus* especially susceptible to local extinction. Long-term studies in central Florida provide two examples of this pattern. The role of fire and succession further complicates the simple interpretation that area and isolation of sand pine scrub habitats explains local extinction. An incidence function which depicts the probability of occurrence in habitat islands of various sizes should be developed for *P. floridanus*. Incidence functions for disturbed and undisturbed habitats would be particularly useful in making recommendations for preserve size and management procedures.

10:30 am REB-15 Marine Mammal Pathology: Review and a Recent Case History. JOHN E. REYNOLDS, III, GEORGE T. HENSLEY, AND DANIEL K. ODELL, Eckerd College, St. Petersburg, Fl. 33733, Jackson Hospital, Miami, Fl., and University of Miami, Miami Fl. 33149. Clear causes of marine mammal strandings and death continue, in many cases, to elude marine mammalogists. Two recent developments enhance both data collection and evaluation of stranded animal pathology: 1) improved communication and cooperation among various agencies, so that personnel are informed of, and can react immediately to, strandings, thereby assuring freshness of anatomical samples, and 2) presence in the field and laboratory of scientists with considerable training in anatomy and pathology. Theoretical and documented causes of cetacean strandings and mortality are reviewed, together with a brief history of the Southeastern Region of the U.S. Marine Mammal Stranding Network. Also, the case history of a killer whale that died in captivity in 1980 is presented to provide an example of how marine mammal pathology can be approached to elucidate a rather subtle etiology: a mycotic aneurysm, probably caused by *Fusarium sp*.

10:45 am REB-16 Studies of the West Indian Manatee (Trichechus manatus) in Tampa Bay. G.W. PATTON, Mote Marine Laboratory, 1600 City Island Park, Sarasota, Fl. 33577. Distribution, dive time, relative abundance and possible forage areas of manatees were studied focusing on warm water effluents. A boat survey procedure proved to be ineffective for accurate abundance estimates. Thirty-two aerial surveys (including one by helicopter) yielded 467 manatee sightings and 221 dolphin (Tursiops truncatus) sightings between June 15, 1979 and March 15, 1980. The passage of the season's first cold front marked a distinct shift in the manatee distribution pattern. A previously unreported associate, Rachycentron canadus (cobia), was noted accompanying manatees in one area. (Funded by Tampa Electric Company.)

SATURDAY 11:00 am John Young Museum and Planetarium, The E. James Strates Room

BUSINESS MEETING: Florida Committee on Rare and Endangered Plants and Animals

LLEWELLYN M. EHRHART, University of Central Florida, presiding

GEOLOGY AND HYDROLOGY

FRIDAY 8:30 am Junior Achievement Center, Room 1

SESSION A: Hydrology

DANIEL P. SPANGLER, University of Florida, presiding

8:30 am GHY-1 Hydrogeology of Lake Wauberg and Vicinity. S. CARL OPPER AND DANIEL P. SPANGLER, Department of Geology, University of Florida, Gainesville, FL. 32611. Basic hydrologic relationships between lakes, wetlands, shallow water aquifers, and the Floridan Aquifer are becoming increasingly important to Florida. This is especially true where varied recreational interests are so intimately involved. Such is the case with Lake Wauberg and the southern portion of the Paynes Prairie State Preserve in Alachua County. A detailed geologic framework and hydrologic budget is currently nonexistent. Temporal and spacial recharge-discharge relationships are under study through a recently installed monitoring system consisting of 12 piezometers. No surface streams enter the lake. A small outlet discharges to Paynes Prairie via Sawgrass Prairie and Chapula Pond.

8:45 am GHY-2 Analysis of Direct Rainfall Inputs into Shark River Slough. ROSE M. LEW, M. FLORA AND P. ROSENDAHL, Ph.D. South Florida Research Center, Everglades National Park, P. O. Box 279, Homestead, FL 33030. Thiessen polygon analysis was used to estimate direct inputs into the 100,000 Ha Shark River Slough. Comparisons of precipitation inputs were made based on data collected bi-weekly during a 22-month period, among raingauge networks containing 87, 29, 11 and 3 gauges. These results were also compared with a less dense but long-term, three-station network which was monitored daily. Data from the three long-term weather stations were also used to compute recent historic rainfall into the slough on a monthly and yearly basis, allowing for a comparison between managed surface water inflows and uncontrolled precipitation contributions to the slough. Previous methods used to monitor rainfall to the slough were also reviewed and recommendations made for future precipitation monitoring.

9:00 am GHY-3 Soil Thickness Within a Large South Florida Slough. MARGARET M. CALVERT, P. ROSENDAHL, Ph.D., AND D. SIKKEMA, South Florida Research Center, Everglades National Park, P.O. Box 279, Homestead, FL 33030. Soil thickness measurements were made at 670 sites along four transects in Shark River Slough, Everglades National Park and statistically related to marsh vegetation density. Hydrologic criteria were utilized to identify open marsh, intermediate vegetation and dense vegetation, with the greatest impedance to surface flows occurring within the dense zones. When soil thickness measurements were taken at 30.5 and 305 cm intervals, a statistically significant relationship with vegetative density was calculated. Measurements taken at 183 m and 1.61 km intervals proved too broad to reflect such a relationship. Soil thickness profiles illustrate that variability in soil thickness with respect to the irregularity of the surface of the basement rock and the overall geometry of the slough tend to obscure the vegetative density and soil thickness relationship.

9:15 am GHY-4 Lateral Permability Variations in the Shallow Water Table Aquifer Adjacent to Cypress Ponds. RICHARD A. STROSS AND DANIEL P. SPANGLER, Department of Geology, University of Florida, Gainesville, FL 32611. Water table gradients in the unconsolidated sediments adjacent to certain Cypress ponds in Florida are steeper on the downgradient side. Four ponds in Alachua, Lake, and Charlotte Counties were investigated. Results thus far indicate a decrease in permability of the soils on the downgradient sides of the ponds. This may be due to an accumulation of very fine material in the pore network through time. The nature of this material is currently being investigated.

9:30 am BREAK

9:45 am GHY-5 Numerical Analysis of Stormwater Runoff. KENNETH WEBER, Dept. of Geology, Univ. South Florida, Tampa, FL 33620. Stormwater runoff was sampled at four locations during a storm event in the city of Live Oak, Florida. The sampling locations were divided between urban and suburban sections of the town. Eighteen parameters were analyzed for, including selected trace metals and major elements. Basic statistical analysis, factor analysis, and crosscorrelation analysis were employed to delineate the chemical processes involved in the runoff. Urban section runoff was characterized by two distinct inputs: trace metal enrichment from pavement, and a maritime rainfall and background element input. Suburban section runoff was marked by its complexity and lack of easily-defined groupings of elements. Levels of toxic elements above E.P.A. criteria were found at all sampling sites. Health concerns are paramount because the runoff water is recharged directly to a drinking-water aquifer.

10:00 am GHY-6 Pan Evaporation Coefficient Determination. S. F. SHIH, University of Florida, IFAS, AREC, P.O. Drawer A, Belle Glade, Florida 33430.

When adequate records of evapotranspiration (ET) for a vegetation are not available, the pan evaporation method is a widely used technique to estimate the ET. However, lot of difficulty is involved in the determination of pan evaporation coefficient which is a converting factor used to form a relationship between pan evaporation and evapotranspiration. In general, the evapotranspiration data was gathered from the lysimeter study. But the lysimeter data always involve an oasis effect. In order to detect this effect, an extensive study on pan evaporation was conducted at different sites (both lysimeter and field). The open pan data was used to correct the oasis effect. The results indicated that the correction factor varied from 10 to 30% depending upon the growth season, growth stage of vegetation and climatic factors. These correction factors were used to adjust the ET data obtained from lysimeter.

10:15 am GHY-7 Response to Recharge in the Principal Artesian Aquifer and the Floridan Aquifer in the Upper Suwannee River Basin, South-Central Georgia and North-Central Florida. RON CERYAK, Suwannee River Water Management District, Rt. 3, Box 64, Live Oak, FL 32060. The Oligocene and Eocene carbonates that comprise Georgia's principal artesian aquifer and Florida's Floridan Aquifer outcrop in the upper reaches of the Upper Suwannee River Basin. This aquifer dips southeast beneath Miocene and younger coastal plain sediments and underlies all of the coastal plain of Georgia and peninsular Florida. The aquifer is recharged generally in the outcrop area and locally wherever the overlying confining sediments are thin, discontinuous, removed, or leaky. Recharge areas have the highest ground-water level fluctuation (33 feet/year), and water levels respond immediately to rainfall. One to two inches of rainfall causes a two- to five-foot positive response in water levels. As the distance from the recharge area increases, water levels fluctuate less (3 feet/year), and there can be up to three weeks of lag time in response to a rainfall event 70 miles from the recharge area.

10:30 am GHY-8 Hydrogeologic Characteristics of the Floridan Aquifer in the Kissimmee Planning Area Using Geologic and Geophysical Logs. JON E. SHAW AND SHARON M. TROST, South Florida Water Management District, P.O. Box V, West Palm Beach, Florida 33402. The Kissimmee Planning Area (KPA) of the South Florida Water Management District (SFWMD) encompasses an area of approximately 3500 square miles including parts of Orange, Osceola, Polk, Highlands, Glades and Martin Counties. A Floridan aquifer monitoring network has been established in this area by SFWMD in a cooperative program with the U. S. Geological Survey, Water Resources Division, Orlando, Florida. Geologic cross sections are illustrated with the aid of geophysical logs. Gamma ray surveys are especially useful in delineating geologic formations and marker beds. Corrected flow logs indicate areas of greatest flow which are separated by semipermeable layers within the Floridan aquifer. These various producing zones are also delineated by temperature logs. The stratigraphy may thus be correlated to the hydrogeologic characteristics of the Floridan aquifer within the KPA.

10:45 am GHY-9 Application of Resistivity Methods to Regional Hydrogeologic Surveys in Collier Co., FL. MARK STEWART AND THEODORE LIZANEC, Geology Dept., University of South Florida, Tampa, FL 33620. Direct current electrical resistivity surveys have been used in a regional study of the shallow aquifer in southwest Florida. Resistivity cross-sections were constructed by completing vertical electrical soundings every 0.25 miles along survey lines up to 14 miles long. The resistivity data were automatically solved and plotted as resistivity cross-sections using computer processing. Zones of reef facies or pore waters of high resistivity can be efficiently located with resistivity surveys. The high resistivities of these two targets allow them to be easily distinguished on the resistivity cross-sections. Very low resistivities (<30 ohm-m) are associated with units saturated with pore waters of high conductivity. Low resistivity zones do not occur with a readily predictable pattern. The depths to resistivities less than 30 ohm-m vary from over 100' to less than 15'. High conductivity pore waters are found at shallow depths well inland from the coast.

FRIDAY 11:00 am Junior Achievement Center, Room 1

BUSINESS MEETING: Geology and Hydrology Section

RICHARD N. STROM, University of South Florida, presiding

FRIDAY 8:30 am Junior Achievement Center, Room 2

SESSION B: Geology I

RICHARD N. STROM, University of South Florida, presiding

8:30 am GHY-10 Reconnaissance study of the post-Eocene stratigraphy of central Collier County, Florida. R. STEVE PEACOCK and SHERWOOD W. WISE, JR., Florida State University, Tallahassee, FL 32306. From Sunniland in north-central Collier County south to Alligatory Alley, the top of the Ocala Limestone dips in excess of 23 ft/mile producing an expanded sequence of Tamiami, Hawthorn, and presumed Oligocene age sediments. Beneath the sandy Tamiami limestone lies a green sandy dolosilt (commonly referred to as a "green clay"). This and an underlying clastic/limestone sequence are now placed in the Hawthorn by some workers. In eastern Collier County these sediments grade into coarse clastics (at least 200 ft thick) which contain quartz pebbles. Lower down the Hawthorn units become more phosphatic and x-ray analysis shows the presence of polygorskite, the first significant clay mineral accumulation down-section ("clays" X-rayed higher up in the section were predominantly dolosilts). The presumed Oligocene sediments below the Hawthorn are somewhat atypical compared to other parts of the state due to a high quartz sand and silt content.

8:45 am GHY-11 Lithostratigraphy of the Hawthorn Formation and Suwannee Limestone of northern Pine Island, Lee County, Florida. ROLAND S. BANKS AND THOMAS M. MISSIMER, Missimer and Associates, Inc., 1031 Cape Coral Pkwy., Cape Coral, FL 33904. A 307 m deep test well (1622) was recently drilled on Pine Island north of Pineland. About 114 m of phosphatic carbonates and clastics of the Hawthorn Formation occur in well 1622. Three cycles of deposition, present in the Hawthorn Formation below the regional disconformity, can be traced 23 km south along Pine Island to Sanibel Island through eleven wells.

Well 1622 also penetrated 145 m into the Suwannee Limestone. The characteristic non-phosphatic, tan, calcarenites of the Suwannee Limestone are separated by thin beds of calcareous clays and hard dolomites. There is a strong correlation between the occurrence of dolomitic sediment and zones of high permeability.

9:00 am GHY-12 Stratigraphy of the 'silex' bed (Miocene), Ballast Point, Tampa, Florida. RICHARD L. HUMMELL, Florida State University, Tallahassee, FL 32306. At a newly excavated site, the 'silex' bed is a heterogeneous, lateritic clay residuum. It is comprised primarily of a tan, orange, red and light grey mottled, fossiliferous, fine sandy clay overlying dark grey to green to blue, fossiliferous clays and silty clays in which the entire fauna and flora are preserved as siliceous pseudomorphs. This residuum represents the upper part of the Tampa Formation, which at Ballast Point, appears to have been a patch reef composed essentially of in-situ *Montastrea tampaensis silicensis* (Vaughan) and slightly transported *Goniopora ballistensis* Vaughan, *G. matsoni* Vaughan, and *Porites floridaeprima* Bernard. The fauna includes many other species of Cnidaria, plus molluscs, benthic foraminifera and root casts of a marine plant.

9:15 am GHY-13 Benthic Testacida (Sarcodina, Protozoa) and their application as biological indicators. HAYDEE LENA-HERNANDEZ, Florida Institute of Technology, Melbourne, FL 32901. The guild of Testacida from different water bodies of South Brevard County (Florida) were studied and correlated with the characteristics of the environment. It was determined that: a) the shell composition is dependent on the available exogenous material, b) the quantity and development of some shell structures (e.g. spines) depend on the type of sediment, and c) the number of *formae* of some species (e.g. *Centropyxis aculeata*) depends on temperature variations. The value of benthic Testacida as biological indicators and their possible use as paleoecologic and pollution indicators are discussed.

9:30 am BREAK

9:45 am GHY-14 Late Stage Diagenesis of Selected Florida Cherts. MARK G. NUCKELS, University of South Florida, Tampa, FL 33620. Weathered cherts are typically zoned with a white, porous siliceous rind of tripoli followed by a dark impurity band which is in sharp contact with the tripoli exterior and gradational to the interior. A diagenetic sequence is described to explain this zonation. The precursor phase (opal-CT) first inverts to micromossaic quartz, which retains the impurities and fabric of the precursor. Crystal size is small (1-30u) and the grains show convolute boundries, undulatory extinction and disseminated impurities. Diagenesis continues by grain growth, grain boundry migration, and impurity segregation to form microgranular quartz, which has a larger crystal size (1-100u), simplified grain boundries with fewer convolutions, more equant grain geometry, and segregated impurities. Weathering produces a tripoli rind by increasing grain size and porosity/permeability. Impurities are removed or concentrated in zones in the rock. Dissolution of silica may contribute to the formation of the tripoli rind.

10:00 am GHY-15 The Mid-Tertiary to Recent Stratigraphy in Putnam Co., Florida. RONALD A. LEROY AND THOMAS M. SCOTT, Fl. Bureau of Geology, 903 W. Tenn. St., Tall. Fl. 32304. The Mid-Tertiary to Recent stratigraphy in Putnam County, Florida, includes the early middle Eocene Lake City Limestone, the late Middle Eocene Avon Park Limestone, the late Eocene Ocala Group, the Miocene Hawthorn Formation, and overlying post-Hawthorn units. The emphasis of this study is placed on the Hawthorn Formation. The Hawthorn consists generally of soft, sandy, often phosphatic dolosilts in the upper portion and hard sandy phosphatic limestones and dolomites in the lower portion. Dipping generally to the east, the formation is absent in a southeast part of the county and exceeds 46 meters in thickness in the north and west central portions. Relatively recent well and core drilling has provided the data and coverage necessary for detailed mapping of the formations in the county. X-ray diffraction analysis and thin sections are used as supplementary tools in mineralogical, depositional, and diagenetic determinations.

10:15 am GHY-16 Neogene Stratigraphy of the Apalachicola Embayment. WALTER SCHMIDT, Florida Bureau of Geology, 903 W. Tenn. St., Tall., Fl. 32304. The Apalachicola Embayment contains a thick sequence of sediments that extends northeastward from the mouth of the Apalachicola River as far as the Georgia-Florida boundary. The shallower deposits (Quaternary and Neogene rocks) are gently downwarped towards the southwest in the direction of the Gulf of Mexico. The outcropping units are predominantly argillaceous, sandy shell beds, whereas the down-dip equivalents are sandy limestones and sandy biocalcarenites. This calcareous wedge of sediments contains a prolific and diverse microfauna dominated by benthic and planktic foraminifera, and calcareous nannofossils. Two formations, the Bruce Creek Limestone and the Intracoastal Formation, are recognized and mapped throughout the coastal area of the embayment. These formations have been dated as Middle Miocene and late Middle Miocene-Late Pliocene respectively.

10:30 am GHY-17 The Paleoextent of the Miocene Hawthorn Formation in Peninsular Florida. THOMAS M. SCOTT, Fl. Bureau of Geology, 903 W. Tenn. St., Tall., Fl. 32304. The present erosional limit of the Miocene Hawthorn Formation extends roughly from northern Pinellas and Hillsborough counties eastward into northern Polk county then swings through Lake, Marion, Alachua, Columbia, Suwannee and Hamilton counties. East and south of this line the Hawthorn is present and generally thickens down-dip. West and north of this line the Hawthorn has been eroded leaving only isolated remanents or is entirely removed. The minimum paleoextent of the Hawthorn Formation is inferred from the occurrence of the replacement chert in the Ocala Group and Suwannee Limestone. It is believed that silica was released from the Hawthorn during weathering and replaced the subjacent limestones. The possible sources for the silica include diatoms and weathering of clay minerals. The line delineating the minimum paleoextent runs north from Pasco county through Hernando, Citrus, Levy, Dixie(?), Gilchrist, and Lafayette(?) counties. It is quite possible that the Hawthorn Formation extended beyond this limit. However, all indications of this have been removed.

FRIDAY 11:00 am Junior Achievement Center, Room 1

BUSINESS MEETING: Geology and Hydrology Section

RICHARD N. STROM, University of South Florida, presiding

FRIDAY 12:45 pm John Young Museum and Planetarium, The Blalock Auditorium

JOINT SPECIAL PRESENTATION: Geology and Hydrology Section and Science Teaching Section

The Geology of U.S. National Parks through Six-Screen Panoramas. FRANK B. KUJAWA, Department of Chemistry, University of Central Florida, Orlando, FL 32816.

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

FRIDAY 3:00 pm Junior Achievement Center, Room 1

SESSION C: Coastal Dynamics

RICHARD A. DAVIS, University of South Florida, presiding

3:00 pm GHY-18 The relationship between grain size, beach slope, and wave climate in Brevard county, Florida. JAMES E. CLAUSNER, DONALD B. STAUBLE, AND J. ERNEST BREEDING, JR., Florida Institute of Technology, Dept. of Oceanography and Ocean Engineering, Melbourne, FL 32901. An analysis of field measurements of the Brevard county, Florida coastline indicates that both the grain size and beach slope increase as one proceeds southward from Cape Canaveral Inlet towards Sebastin Inlet. Mean diameters increase from 0.18 mm to 0.42 mm, slope increases from 1:36 to 1:9. These results are consistent with an increase in wave energy southward of the Cape. Such an increase in wave energy is possible due to refraction of the dominant waves which arrive from the northeast. The wave energy distribution deduced from field measurements is compared with a prediction of wave climate obtained from wave packet trajectories. Accurate prediction of wave energy distribution patterns will allow better coastal planning. This research is partially supported by the Coastal Sciences Program, Office of Naval Research.

3:15 pm GHY-19 Textural Change of Sediment During Beach Nourishment of the Beaches at Indialantic-Melbourne Beach, Fla. MARK HANSEN, AND D. K. STAUBLE, Department of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, Fl 32901. The textural difference between native and borrow material determines the stability of a beach fill. Success of a beach nourishment program is dependent upon the accuracy of theoretical modeling. To date, little research has been performed to verify theoretical models. Sediment samples were taken weekly along beach profiles and were analyzed for grain size distributions. Volumetric sediment change was calculated from the beach profiles. The field data was used to test the accuracy and reliability of fill and renourishment factors in theoretical models of beach nourishment.

3:30 pm GHY-20 A Detailed Study of Immediate Response of Beach Nourishment. L. E. PARSON AND D. K. STAUBLE, Department of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, Florida 32901. Until recently a very small percentage of beach nourishment studies have monitored the immediate physical response of nourishment fill. Sediment, borrowed from the Cape Canaveral turning basin, was transported by truck and deposited on Indialantic beaches in order to restore the receding shoreline. Profiles and wave data were taken regularly before and after the completion of dumping and continued on a weekly basis. The immediate changes in the profiles are recorded and compared by computer analysis. This is done to assess the short term volume changes of the beach as the fill profile responds to the physical processes. Due to the popularity, but unfortunate high cost of beach nourishment, it is imperative that projects be accurately monitored and documented. With this data base, models can be verified.

3:45 pm GHY-21 Evaluation of performance of the beach nourishment project at Cape Canaveral, Fla. through the use of aerial photography. F.L. HUSHLA AND D.K. STAUBLE, Department of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, Fla. 32901. The beach extending 2.1 miles south of the Canaveral Harbor channel was nourished by the Army Corps of Engineers from June 1974 to March 1975. A volume of 2,300,000 cubic yards of sand and shell material was placed on the beach. Aerial photographs before, immediately following, and five years after the nourishment were examined. Shoreline changes are measured using a common-scale mapping technique. A map portraying the evolution of the project area has been developed; and the rate of shoreline position change is measured. A technique utilizing a stereoscope and parallax bar is used to construct beach profiles from the aerial photographs. Using this technique, rates of volume change for the fill can be estimated, and the long term evaluation of the performance of the project can be examined.

4:00 pm BREAK

4:15 pm GHY-22 Geochemical Assessment of the Environmental Impact of Offshore Drilling Operations on the Texas Flower Gardens , DAVID B.MEYER, J.H.TREFRY, and R.P.TROCINE, Department of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, FL 32901. Increased oil and gas exploration on the outer continental shelf has provoked controversy as to the fate of the Texas Flower Gardens, two coral reefs 200 km south of the Texas-Louisiana border. The discharge of spent drilling fluids and other materials associated with offshore drilling operations may release high concentrations of potentially toxic trace metals to the marine environment. As sediments are the ultimate sink for pollutants, a study of the sedimentology and trace metal geochemistry of the sediments was carried out and the relationship between trace metals and sediment parameters such as grain size, $CaCO_3$ content, and clay mineralogy was investigated. Of the trace metals analyzed, Ba was the only element to show significant differences in concentration. Levels varied from a high of 15,000 ppm near the rigs to background levels of 500 ppm in the sediments at the base of the reef.

4:30 pm GHY-23 Bathymetry and Sedimentology of the Nearshore Gulf of Mexico off Pinellas County, Florida. JAMES K. CULTER, GEOFFREY W. PATTON, ROBERT E. YARBROUGH and MARK L. GALLO, Mote Marine Laboratory, 1600 City Island Park, Sarasota, FL 33577. Bathymetric profiles and sediment analysis were conducted on three east-west transects from the littoral zone of the barrier islands to 16.0 km. offshore, as a portion of an Environmental Impact Baseline Study. Video camera surveys identified six substrata types; silty sand, sand, shelly sand, coarse shell, hard bottom and limestone outcroppings. Relative percentage composition of each type of substratum for each transect was estimated from video coverage. Quantitative sediment analysis was performed on samples from selected soft bottom stations. Results indicated that sediments of these stations range from very fine sand to coarse sand (mean particle size, Ø scale), with fine sand predominating. Hurricane Pass was found to contribute fine sediments to nearshore stations. Evidence of offshore sediment transport was also observed.

4:45 pm GHY-24 Origin and Development of a Central Florida Gulf Coast Barrier Island: Anclote Key, Pasco County, Florida. BERNARD J. KUHN AND RICHARD A. DAVIS, Department of Geology, University of South Florida, Tampa, FL 33620. A total of 24 cores were taken by vibro-coring along both transverse and longitudinal profiles for use in stratigraphic analysis of Anclote Key. Samples were collected from modern environments and sediment textural parameters were analyzed and used for comparison with the cores. Based on the stratigraphic sequence and sedimentological features Anclote Key appears to represent upward accretion of subtidal shools on a bedrock surface. Fauna and flora were collected and identified from the various units. Peat horizons and shell material provided substances for radiocarbon and amino acid age determination to be used in establishing a more precise chronology for the sequence of events associated with the development of this barrier. Navagational charts and aerial photography were used to reconstruct the morphological changes during historical times.

FRIDAY 3:00 pm Junior Achievement Center, Room 2

SESSION D: Geology II

SHERWOOD W. WISE, JR., Florida State University, presiding

3:00 pm GHY-25 Geology of Placer Gold Deposits on the Río Nechí, Columbia, South America. ALEXANDER W. RITCHIE AND ABRAHAM ROSENZWEIG, Department of Geology, University of South Florida, Tampa, FL 33620. Extensive gold placer deposits are located along the upper Río Nechí, Department of Antioquia, Columbia, near 7°24'N, 74°50'W (approximately 140 km north of Medellín), on the northern terminus of the Central Cordillera of the Andes Mountains. The area is underlain by Paleozoic and older metamorphic rocks intruded by Mesozoic acid rocks which are the source of the gold. Hydraulic mining yields gold from: 1) active river gravels in the Río Nechí and its tributaries, 2) older (Pleistocene?) terrace gravels incised by the river system, and 3) colluvial soils developed on the metamorphic and igneous bedrock. Gold flake morphology indicates coexistence of gold from local and distant sources. The heavy mineral suite in the alluvium is consistent with both igneous and metamorphic origins. Relative amounts of heavy minerals in the suite vary significantly and may allow identification of source areas. This study was supported by Belmac Corporation of St. Petersburg, Florida.

3:15 pm GHY-26 Some preliminary calculations concerning heat flow and isograd migration during regional scale folding. GRENVILLE DRAPER AND RICHARD BONE. Dept. of Physical Sciences, Florida International Univ. Miami, Fl 33199. We have used a two dimensional, finite difference, heat conduction model to quantitatively examine some thermal effects of regional scale folding. Preliminary results show that folding of an isothermal surface occurs, but that its maximum amplitude is smaller than that of the folded rock layers. The isothermal surface returns to the horizontal after folding has ceased. The degree to which this affect develops is controlled by the scale of the folds and the rate of fold development. In larger scale folds of the order of tens of kilometers, complex metamorphic overprinting patterns are predicted because the isograd surface is dynamic and not stationary. Field studies in areas where such effects can be observed could yield valuable information on the rates of metamorphic and tectonic processes.

3:30 pm GHY-27 A Comparison of Geophysical Logs with Four Cores in Gulf County, Florida. THOMAS KWADER, N. W. Florida Water Management District, Rt. 1 Box 3100, Havana, Florida, 32333. Geophysical logging of water wells and test holes has become one of the most popular methods for lithologic correlation and for inferring hydrologic characteristics of water bearing strata. Many factors can influence a log and it is strongly advised to confirm interpretations with other types of logs, sample cuttings and cores whenever possible. Four cores (278 ft. to 462 ft., in depth) were compared with their respective Natural Gamma, Neutron, Density, Electric and Caliper logs to determine their response to changes in porosity, lithology, bore-hole diameter, casing effects and pore fluid chemistry. Small changes in bore-hole diameter (1-2 inches) can significantly affect neutron, density and shallow focused electric logs. It is imperative to run a caliper on every hole to account for any apparent anomalies. Proper interpretation of geophysical logs can be the most useful tool for the optimum understanding and development of ground water resources of the hydrogeologist.

3:45 pm GHY-28 Heat Flow in the Southeastern Gulf Coastal Plain.William T. DEES and Douglas L. SMITH,Department of Geology,University of Florida,Gainesville,FL 32611.Twenty-four new heat flow values from Louisiana,Mississippi,Alabama,and panhandle Florida range from 0.6 heat flow unit (μcal/cm^{2}sec) to 2.5 hfu.Relatively higher values (six sites averaging 1.75 hfu)are characteristic of northern Louisiana,with geothermal gradients of 35-44°C/km recorded in this area.Positive thermal anomalies were recorded in Hinds County (1.5 hfu) and Adams County (1.4 hfu) in Mississippi,with relatively high gradients continuing into extreme western Florida (24-27°C/km).This zone of elevated thermal gradients and heat flow values can be correlated with reported patterns of salt intrusives across the region.Exploitable thermal resource potential for certain portions of the Gulf Coast region is encouraging but not clearly resolved.

4:00 pm BREAK

4:15 pm GHY-29 Residual Effects of the February 4, 1976 Earthquake in Guatemala, Central America. DAVID S. SMITH AND ALEXANDER W. RITCHIE, Department of Geology, University of South Florida, Tampa, FL 33620. A major earthquake (magnitude 7.5, Richter scale) occurred in Guatemala, Central America on February 4, 1976. The main epicenter was located on the Motagua fault system near 15.27°N, 89.25°W, approximately twenty kilometers west of Los Amates, south of Lake Izabal. A secondary earthquake occurred along the Mixco fault which lies normal to the Motagua system, with the maximum damage (Mercali IX) centered near San Martin Jilotepéque. Many of the population centers received very heavy property and road damage as well as great loss of life. Toward, widespread population redistribution, generally unusable roads, extensive landslide scars and a higher base level in some of the drainage systems remain as evidence of the tremendous energy generated by this rupture. This study was supported by the Instituto Geográfico Nacional de Guatemala.

4:30 pm GHY-30 Multi-Screen Panoramas of American National Parks: A Field Trip Simulation Technique for Geology. FRANK B. KUJAWA, Department of Chemistry, (Geology), University of Central Florida, Box 25000, Orlando, Florida 32816. The geologic features in many national parks are so classic and dramatic that they are commonly used as examples in geology courses. Unfortunately, the photographing of some features, such as mountain ranges and canyons, normally requires a choice between a distant view showing little detail and a closer view that shows only a small portion of the feature. However, multi-screen (six or even three-screen) panoramas, showing a continuous scene, do allow a combination of detail and context approaching that available on actual field trips. Moreover, the multi-screen format is ideal for comparing views not simultaneously available in the field, such as the different stages in a process, successive close-ups of an object, or geographically separated features. This paper will cover techniques of photography, production, and presentation of multi-screen simulated field trips.

4:45 pm GHY-31 The Florida Basement: A Proposed History. Douglas L. SMITH, Department of Geology, University of Florida, Gainesville, FL 32611. The Suwannee Basin deposits of undeformed Ordovician and Silurian sandstone and shale which lie 0.9 to 1.9 km below the surface in northern Florida are lithologically similar to deposits in western Africa from Senegal to Sierra Leone and suggest an African location for the Florida basement in the early Paleozoic. Deep (2.7 - 5.5 km) bore holes in central and south Florida penetrate Mesozoic volcanic rocks characterized by rhyolites, ignimbrites, and alkali basalts, which are interpreted as representative of a Triassic hot spot that helped to initiate rifting and the opening of the North Atlantic. The position of the hot spot dictated that the northern Florida Suwannee Basin area and a Pan-African granitic complex in central Florida remain appended to North America as radially propagating rifts from the hot spot created a new configuration of plate boundaries from those of the Paleozoic. Other continental terrains adjacent to southern Florida were either altered and foundered to underlie the Bahamas or stayed with Africa and/or South America.

MEDICAL SCIENCES

FRIDAY 10:15 am John Young Museum and Planetarium, Laboratory

MICHAEL J. SWEENEY, University of Central Florida, presiding

10:15 am MED-1 Socio-Academic Factors Affecting the Health Status of College Students. M. CLARE WILSON and M. YAŞAR IŞCAN, Student Health and Dental Services and Department of Anthropology, Florida Atlantic University, Boca Raton, FL 33431. This paper seeks to illustrate a possible relationship between students health and their academic education. The study consists of over six thousand visits to a University based health clinic in three consecutive winter quarters. Data collection was based on a standard student health daily log consisting of 19 separate categories of health problems. It has been found that visits to the clinic correspond to periods just prior to examinations. Among the reasons for visits, the most common ones were due to respiratory ailments and dermatologic conditions. Based on this, it is our conclusion that in treating the total person, the Student Health Service must consider the cyclical socio-academic pressures exerted on the students and the ensuing health problems.

10:30 am MED-2 A Bone Infection Caused by _Phialophora_ _richardsiae_ (Nannf.) Conant. BIENVENIDO G. YANGCO, Department of Medicine, University of South Florida, Tampa, FL 33620 and DIANE TeSTRAKE WAGNER-MERNER, Biology Department, University of South Florida, Tampa, FL 33620. _Phialophora_ _richardsiae_ (a dematiaceous fungus) infection is rare and has been reported previously only in several subcutaneous abscesses and a case of bursitis. A patient is described with a bone infection due to _P_. _richardsiae_. Morphological and physiological characteristics of this fungus are compared with other isolates and species of _Phialophora_ which cause disease in man. Antifungal susceptibility studies showed that this organism is sensitive to ketoconazole, miconazole and amphotericin B and resistant to 5-fluorocytosine and clotrimazole at achievable drug serum levels.

10:45 am MED-3 The Effect(s) of Hyperthermia on in vitro Immune Function.* DEBORAH A. NICKERSON, Department of Biology, University of South Florida, Tampa, FL 33620. Increasing interest has been generated in hyperthermia as an alternative treatment modality for cancer. The objective of this investigation was to define the influence of hyperthermia on the functional abilities of splenic and lymph node cells from C57BL/6 ($H-2^k$) mice. Heat treatments were accomplished utilizing thermoregulated circulating water baths with a maximum temperature variation of ± 0.1°C Studies to be reported include: (a) determinations of mitogen responsiveness to Concanavalin A and lipopolysaccharide (LPS) (phenol extract of Escherichia coli strain 055:B5); (b) assays of the in vitro antibody response potentials to a T-cell dependent antigen, sheep red blood cells and T-cell independent antigen, trinitrophenylated-LPS; and (c) tests of cell-mediated immunity with mixed lymphocyte reactions to DBA/2 ($H-2^d$) splenocytes. The correlation between hyperthermic immune modulation and tumor therapy will be discussed. *(Supported by the American Cancer Society, Florida Division Inc. #F80USF-2).

11:00 am MED-4 Foreign Body Reaction in the Lung to Intravenously Injected Biomaterials. E. FITZGERALD, R. WORTH, S. E. COLEMAN, C. I. HOOD, F. J. SCHOEN AND M. ROBINSON, VA Medical Center and Dept. of Pathology, Univ. of Fla., Gainesville 32602. The inflammatory response to a foreign material may be affected by the surface area of the implant. To test this hypothesis, we employed a murine model in which pulmonary granulomas develop after injection of divinyl benzene copolymer beads into the tail vein. Beads were sieved into 3 groups with diameters of 30-45, 45-53, and 53-70 μm. 10,000 beads were injected into each animal and the pulmonary granulomas in each group were compared microscopically at intervals from 6 hours to 3 weeks. The results indicate that the rate of granuloma formation is the same, and that small beads produce a granulomatous response proportionately comparable to that produced by the Standard Bead Model (30-70 μm). It is expected that after the other two ranges (45-53 & 53-70 μm) have been completely tested, the same results will occur, reflecting that the size of the foreign material does not significantly affect the rate of the granulomatous response.

11:15 am MED-5 Effect on the Foreign Body Response in Mouse Lung of the Injection of Sieved Divinyl Copolymer Beads (47 to 53 μm diameter). SYLVIA E. COLEMAN, C. IAN HOOD, FREDERICK J. SCHOEN AND MINA ROBINSON, VA Medical Center, and Univ. of Florida, Gainesville, 32602. We have studied the inflammatory response to foreign bodies using divinyl copolymer beads (Biobeads SX-8, Biorad) which are injected into the tail vein of albino female mice from where they embolize to the lung. The sizes of the beads range from 30 to 70 μm. Granulomas form around the beads, and the extent of the response varies with the diameter of the beads. To test the effects of bead diameter, the beads were sieved to a size of 47 to 53 μm. 10,000 beads were injected into the tail vein in 0.5 ml of saline. The results were compared with the response to the whole population of beads. The granulomas were more uniform in size and the early responses (3 to 12 hrs.) more consistent. The maximum response still occurred at 48 hrs. These results indicate that beads of 47 to 53 μm in diameter provide a more accurate baseline for studies which test the effects of anti-inflammatory drugs on the granulomatous reaction.

FRIDAY 11:30 am John Young Museum and Planetarium, Laboratory

BUSINESS MEETING: Medical Sciences Section

MICHAEL J. SWEENEY, University of Central Florida, presiding

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

PHYSICAL SCIENCES

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

SATURDAY 9:00 am Junior Achievement Center, Room 2

JOINT SESSION: Atmospheric, Oceanographic and Physical Sciences

HUGH E. WILLOUGHBY, NOAA, National Hurricane and Experimental Meteorology Laboratory, presiding

(NOTE: see p. 10 for schedule)

SATURDAY 11:00 am Junior Achievement Center, Room 2

JOINT BUSINESS MEETING: Atmospheric and Oceanographic Sciences Section and Physical Sciences Section

HUGH E. WILLOUGHBY, NOAA, National Hurricane and Experimental Meteorology Laboratory, and JOSEPH C. HIRSCHBERG, University of Miami, presiding

SCIENCE TEACHING

FRIDAY 11:00 am Junior Achievement Center, Room 2

BUSINESS MEETING: Science Teaching Section

WITOLD OSTRENKO, The Historical Museum of Southern Florida, presiding

(Abstracts transmitted to Biological Sciences Section and Geology and Hydrology Section)

FRIDAY 12:45 pm John Young Museum and Planetarium, The Blalock Auditorium

JOINT SPECIAL PRESENTATION: Geology and Hydrology Section and Science Teaching Section

The Geology of U.S. National Parks through Six-Screen Panoramas. FRANK B. KUJAWA, Department of Chemistry, University of Central Florida, Orlando, FL 32816.

FRIDAY 1:30 pm John Young Museum and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

SOCIAL SCIENCES

and

URBAN AND REGIONAL PLANNING

FRIDAY 1:30 pm John Young and Planetarium, The Blalock Auditorium

PLENARY SESSION: The Florida Academy of Sciences

HARVEY A. MILLER, University of Central Florida, presiding

SATURDAY 8:30 am Junior Achievement Center, Room 1

SESSION A: Public Policy

WILLIAM MADDOX, University of Central Florida, presiding

8:30 am SUS-1 Improving Human Capabilities. WILLIAM M. TRANTHAM, Florida Keys Community College, Key West, FL 33040. This paper describes a nontraditional course utilizing student resources rather than a textbook approach to maximize human potential. Psychological testing, passive biofeedback instrumentation, color videotape, psychodrama, body language analysis, and behavioral modification are used to identify and improve student capabilities.

8:45 am SUS-2 Impact of CETA Title II-B Upon Participants in Orange and Seminole Counties. DR. DJEHANE HOSNI AND MARY NARAMORE, Economics Department Univeristy of Central Florida, Box 25000, Orlando, FL 32816. An outcome assessment of CETA Title 11-B is undertaken for CETA completers in Central Florida (Orange and Seminole Counties) for fiscal year 1978. The study uses a control group (CETA participants who did not complete the program) to compare them to the completers in order to establish their success in the labor market as attributed to training per se. The model used for the analysis is decomposed into group, training and labor market performance. The group outlines the socio-economic characteristics of the two groups upon enrollment. Training discusses the manpower services rendered, the occupation and length of training. The post labor market experience of the two groups is assessed on the basis of quantitative (employment, income, welfare reduction) and qualitative (job satisfaction, training relatedness of jobs, overall opinion of CETA) criteria.

9:00 am SUS-3 Analysis of Public Service Employment Targeting Objectives for the state of Florida. Dr. DJEHANE HOSNI AND ANDREA LEFFORGE, University of Central Florida, Box 25000, Orlando, FL 32816. The Public Service Employment (PSE) programs funded under CETA (Titles II/II-D and VI) have been the most rapidly expanding part of the nation's employment and training programs designed to assist economonically disadvantaged persons. However, "creaming" or the hiring of the best qualified was experienced so extensively that the 1978 CETA reauthorization amendments were introduced to correct the situation. The purpose of this paper is to analyze whether the reauthorization changes have increased targeting of PSE jobs to the disadvantaged in the State of Florida. The Socio-economic characteristics of the participants before and after the amendments will be examined in the two separate PSE programs.

9:15 am SUS-4 Houston Park Marina: An Attempt to Cooperate with Nature. Sandra K. Barrett, South Florida Regional Planning Council, 1414 N.W. 167 St., Suite 429, Miami, FL 33169. Developers have the reputation of viewing the environment as something to work around at best and to conquer at worst. However, more and more development companies are realizing the longterm need for environmental protection, and also are discovering benefits from sound environmental design in terms of decreased construction cost and aesthetic attractions. Houston Park Marina is an example of such planning. The development will provide hurricane protected dockage for 184 boats, a restaurant, community center and public recreation area. The basin is to be excavated from previously filled land, designed to maintain or improve the flushing of adjacent mangrove communities, riprapped to provide littoral area, and sloped to aid circulation. Liveaboards and boat maintenance are restricted and sewage pumpout facilities are provided. The grounds will be landscaped with native vegetation, all stormwater runoff will be routed to french drains, and a nature boardwalk will serve to educate the public about the value of important wetland systems.

SATURDAY 9:45 am Junior Achievement Center, Room 1

SESSION B: Political Science

SANDRA GUEST, University of Central Florida, presiding

9:45 am SUS-5 North-South, Urban Rural Conflict Among Florida State Convention Delegates. MARK STERN, S. GUEST, R.B. HANDBERG,JR., and W. MADDOX. University of Central Florida, Orlando, FL. 32816. An analysis of Florida State Democratic and Republican Delegates to their respective 1979 conventions is undertaken. Data is drawn from a sample survey with the Republican response rate of 57% (N=1477) and the Democratic response rate of 39% (N=1717). Both regional background and metroplolitan-non-metroplitan place of residence are assessed as variables impacting on delegate socio-economic characteristics,attititudes towards party reform, prior partisan activity, self-defined ideology, and presidential candidate preference.

10:00 am SUS-6 1980 Presidential Election in Florida. WEN-FU P. SHIH, Bureau of Economic and Business Research, University of Florida, 221 Matherly Hall, Gainesville, FL 32611. A national trend of conservatism has swept President Jimmy Carter out of the White House with a landslide victory for Ronald Reagan in the 1980 presidential election. Traditionally Democratic states joined this national trend--Florida was no exception. In Florida, northern and central counties with 90 percent or more voters registered as Democrats had supported Carter. Elsewhere, party affiliation did not play an important role in the election. In general, lower income, less populated, rural counties supported Carter, and higher income, more populated counties with a large percentage of retirees voted for Reagan. The counties which strongly favored Carter or Reagan in the March primary continued to support them. Bush's supporters in the primary most likely voted for Anderson or the Reagan-Bush team in November.

10:15 am SUS-7 Congress in Change: A Year or a Decade of Growing Conservatism. MARK STERN and NANCY SPALDING, University of Central Florida, Orlando, FL 32816. An analsysis of changing congressional voting patterns on key issues, as defined by Congressional Quarterly, is undertaken. Conservative coalition scores, ACA, ADA and Party support scores are examined by party and region from 1964 through 1980. James McGregor Burns' four congressional party hypothesis is evaluated as is the idea of a suddenly emergent new conservative majjority.

10:30 am SUS-8 Methodology for Evaluating Personnell Systems. Ransford C. PYLE, Department of Public Service Administration, University of Central Florida, Orlando, FL 32816. Results of a study of the Gainesville Police Department, using ethnographic field methods, suggest that hitherto little used anthropological methods can be incorporated effectively into the more usual sociometric and statistical methods for evaluating personnell systems.

10:45 am SUS-9 The Effects of Media Use on High School Students' Knowledge of Political Institutions and Political Personalities. Judith N. Knudson, Department of Political Science, University of Central Florida, Orlando, FL 32816. Studies regarding the political socialization of children show a high correlation between levels of political knowledge and media use. Four categories of political knowledge are of interest in this paper: national institutions; the individuals in those offices; state institutions; and the individuals in those offices. Questions to be considered include the differences in knowledge levels of high school students regarding these categories of institutions and individuals; and the relationships between these knowledge levels and media usage including the kind of media used, the level of this use, and the reasons associated with it.

SATURDAY 11:00 am Junior Achievement Center, Room 1

JOINT BUSINESS MEETING: Social Sciences Section and Urban and Regional Planning Section

MARK STERN and WILLIAM MADDOX, University of Central Florida, presiding

LIST OF PARTICIPANTS

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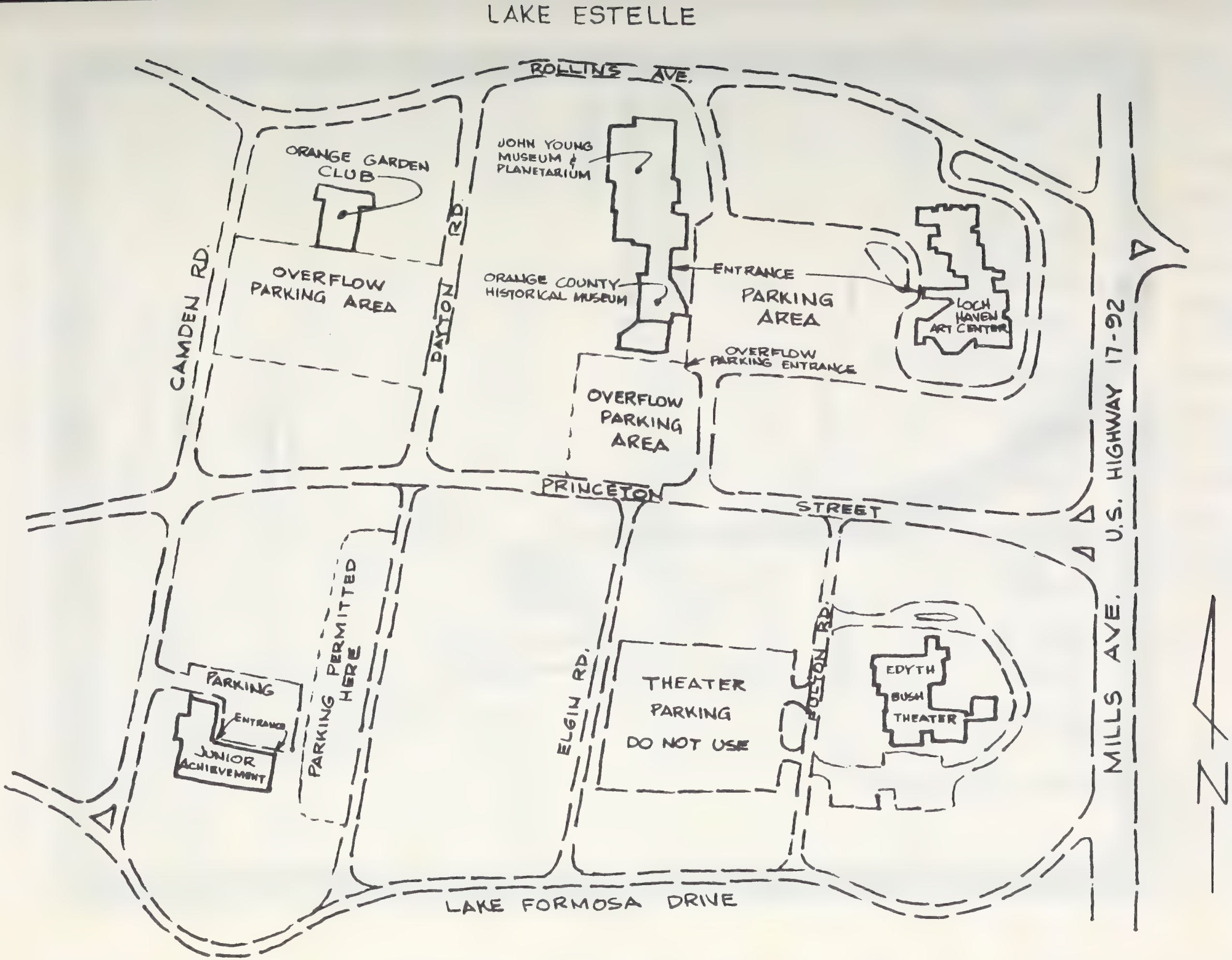
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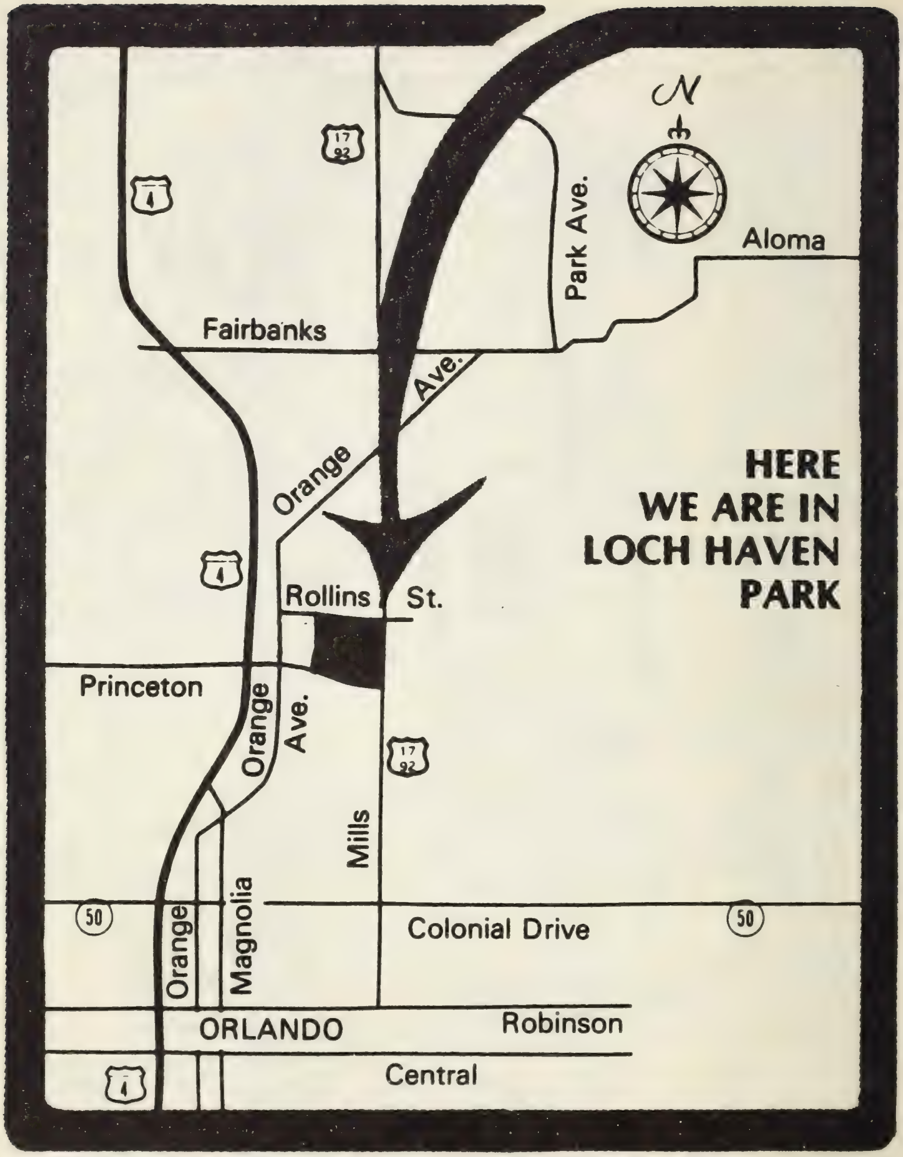
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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

WALTER K. TAYLOR, *Editor* HENRY O. WHITTIER, *Editor*

Volume 45 Winter, 1982 No. 1

Academy Symposium

RECENT ADVANCES IN SHARK BIOLOGY

ALFRED BEULIG

INTEREST in the biology of sharks has continued in recent years as indicated by meetings held in 1974 and 1976 sponsored by The Office of Naval Research and The American Society of Zoologists, respectively.

A substantial amount of research on sharks has been conducted in Florida and because the last major publication devoted entirely to sharks appeared in 1977 [Amer. Zool. 17(2)] it seemed timely to provide a forum in which progress in shark research in Florida could be reported.

Accordingly, at the suggestion of Dr. E. D. Estevez of the Florida Academy of Sciences and with the support of the Academy, I organized a symposium on recent advances in shark biology, which took place at the forty fourth annual Academy meeting in Tampa, 23 March, 1980.

The keynote speaker was Dr. Perry W. Gilbert, Professor Emeritus of Neurobiology and Behavior, Cornell University and former Director, Mote Marine Laboratory, Sarasota, Florida. Regretfully, Dr. Gilbert was unable to provide a written contribution to the present Symposium volume due to pressing personal circumstances. We welcome the participation of an out-of-state biologist, Dr. Leo Demski of the University of Kentucky, who enlightened us on the neural substrate of feeding.

The emerging themes of the symposium centered around sensory capacities and brain structures related to feeding behavior and the behavioral ecology of feeding with special reference to the lemon shark (*Negaprion brevirostris*) as a model system. A final contribution summarizes on-going field studies which characterize shark populations in general in Florida waters.

I thank Dr. E. D. Estevez, Dr. Walter K. Taylor and the Florida Academy of Sciences for their support and cooperation.

SOCIAL AND EXPERIENTIAL FACTORS IN THE RESPONSIVENESS OF SHARKS TO SOUND

Alfred Beulig

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Sarasota, Florida 33580

Abstract: *The responses to low-frequency, irregularly-pulsed sounds of juvenile lemon sharks (*Negaprion brevirostris*) that were born in captivity and deprived of normal experience were measured. These sounds were produced by a mechanical device oscillating a transparent plastic flipper at a frequency of 12.5 Hz. The sounds were known to attract juvenile sharks that were captured in the field but experientially-deprived sharks were not attracted to these sounds in initial tests. The sharks were then provided with opportunities to capture living prey and to experience auditory stimulation associated with wounded, struggling fish. These experiences were not sufficient to overcome the possible inhibitory effect on responsiveness of social isolation during testing. To verify the existence of a social factor the sharks were then tested in groups of three. Their approach-response level indicated attraction and compared favorably with juvenile sharks that had species-typical feeding and rearing experiences. Due to the confounding of social conditions during testing with experience in the present work it is not possible to isolate the roles of experiential and social factors in responsiveness to sounds. Suggestions for further research are made to resolve these issues.*

The capacity of sharks to detect and respond to underwater sound has been well established. Sharks were attracted most readily by broad-band, low frequency, irregularly-pulsed sounds of 20-100 HZ. (Nelson & Gruber, 1963; Nelson, 1967; Myrberg et al., 1969; Banner, 1972).

The biological significance of the attractiveness of pulsed, low-frequency sounds may be their similarity to sounds present in feeding situations. Such sounds are produced by accelerating schools of fish, injured and struggling fish, and feeding animals (Banner, 1972). It would be adaptive for a shark to investigate the source of these sounds as they may be produced by possible prey organisms.

In the previously-mentioned work, test sounds were produced either by electronic sound generating apparatus or tape recorder. Technical difficulties surrounded this work when attempts were made to produce sound frequencies below 20 Hz in the field or in laboratory tanks. It seems possible that biologically significant sounds could exist in the frequency range below 20 Hz and that sharks could be attracted by these sounds. Accordingly, I constructed a mechanical sound producing device (the Ichthyo-Uro Simulator or IUS) which could produce pulsed, broad-band sounds by oscillating a flexible, transparent piece of plastic in a way similar to the caudal fin of a struggling fish. With this device, sounds including frequencies below those produced electronically could be generated. An additional advantage of this technique is that these artificially-produced sounds are more similar to water disturbances created by real struggling fish than electronically-produced sounds.

Preliminary field and laboratory experiments (Beulig, 1974) indicated that the sounds generated by the IUS were attractive to juvenile lemon sharks (*Negaprion brevirostris)* captured in the field. Unconditioned responses to these sounds included investigative and approach behaviors within distances of less than 0.5 m from the apparatus and circling in its vicinity.

Many shark species localize and approach the source of low-frequency irregularly patterned sounds (Zahuranec, 1975). The factors responsible for the development of this response tendency have not yet been identified. It seems reasonable to hypothesize that early feeding experiences and their accompanying auditory stimuli have a significant effect on later responses to sound. Until recently, it has been assumed (see Gruber & Myrberg, 1977) that sharks have a low degree of behavioral plasticity and that their behavioral responses were generally impervious to the effects of experience. If the experience of juvenile sharks could be manipulated at a very early age, it would be possible to determine whether early experiential factors can modify sharks' responses to sound.

Subsequent to the preliminary experiments mentioned above, a litter of 13 lemon shark pups from a moribund female became available for study at the Mote Marine Laboratory, Sarasota, Florida. Because these animals had identical early experiences and were as similar in age, development and genetic constitution as could be expected, I decided to use them in experiments designed to investigate the possible role of altered early experience in responsiveness to mechanically-produced sounds.

MATERIALS AND METHODS—The subjects were a litter of 13 lemon shark pups from the same female. This animal had been caught on a shark line and was in a moribund condition when returned to the laboratory. Before she died the pups were removed from her uteri and placed in a holding tank. Prior to the experiment, they were maintained in this tank and fed cut mullet (*Mugil cephalus)* for 2 mo. Thus, they never experienced the pursuit and capture of living prey and the attendant sensory stimulation, nor did they ever swim in a natural, species-typical environment. When experiments began, the subjects were approximately 50 to 65 cm in length.

Apparatus: Experiments were conducted in an outdoor, circular, cement tank 4.5 m in dia. The bottom was slightly sloped toward a center drain and the depth of sea water was 1 m at the periphery and 1.2 m at the center. The IUS was mounted on a wooden platform over the center of the tank. A circular scoring area 46 cm in radius was marked out in the center (under the IUS) and a narrow annular ring of 91 cm radius was marked out peripheral to this circular area. The ring delineated the area within which behavioral responses to the sound-producing device were scored. The tank for maintaining the sharks was identical with the experimental tank and both had a continuous supply of sea water. The flow of sea water was interrupted in the experimental tank during tests.

The sound-producing device was dubbed the Ichthyo-Uro-Simulator MK III (Tavolga, pers. comm.). It oscillated a flexible plastic flipper 120 cm^2 in area by means of a 1/3 hp electric motor. A 3-speed, V-belt pulley permitted oscillation of the flipper at nominal frequencies of 11, 14, and 22 Hz. The machine could also be run with the flipper removed to provide sounds without large-amplitude hydrodynamic components.

Sounds were monitored with a pressure hydrophone (Chesapeake Instruments) and the output signal was fed into an oscilloscope as well as a tape recorder. Tape recorded sounds were later analysed with a sound spectrograph (Sonagraph, Kay Electric Co.). The oscillation frequency as determined from the oscillogram was found to be 12.5 Hz. Two types of stimuli were presented: (a) sounds produced with the flipper attached, Type I and (b) sounds produced with the flipper removed, Type II.

Procedure: Sharks were captured from the holding tank by dip net and transported to the test tank 46 m away for behavioral observations. A 3-min control observation period preceded each experimental trial. No stimuli were presented during control observation periods but behavioral responses were recorded. Stimuli were presented during 3-min trial periods and responses were noted. A 3-min intertrial interval during which no behavioral observations were made separated control and trial periods. This was done so that residual effects from any trial would be less likely to influence the results of the succeeding one. In all test sessions 6 trials were run and these were separated by 6 control observation periods and 6, 3-min intertrial intervals. This permitted 2 sessions per day with the same subjects, one in the morning and one in the afternoon. Only one type of stimulus was presented in a session and the order of presentation was counter-balanced. That is, if Type I sounds were presented in the morning session one day, the following day Type II sounds would be presented in the morning.

Dependent Measures: The frequencies of the following 4 categories of behavior were recorded: (1) *Initial oriented turn*—a sudden right angle turn toward the signal source at the instant of signal onset and subsequent approach within the scoring area; (2) *Investigative approach*—a turn toward the signal source any time after signal onset, subsequent approach within the scoring area with decrease in speed and orientation of the head toward the signal source; (3) *Circle*—at least one-half of a circuit around the signal source while within the scoring area; and (4) *Avoid*—a sudden change in speed and/or direction with rapid darting away from the signal source after an initial approach to the scoring area. Hereafter, *Initial oriented turns* will be referred to as IOT responses, *Investigative approaches* as IA responses, and *Avoids* as AV responses. *Circles* will not be abbreviated.

EXPERIMENT 1—Each naive subject was individually tested once for its responsiveness to the mechanically-produced sounds. This provided a baseline measure of response levels for the subjects in the subsequent experiments. A Wilcoxon Matched Pairs, Signed Ranks Test (Siegel, 1956) was used to determine the significance of differences in the frequency of behavioral responses during trials and control observation periods. The advantage of a within-subjects design was that it permitted the collection of numerous data points with a limited pool of subjects.

RESULTS—The responses of sharks without species-typical feeding experience observed in isolation (Experiment 1) are in Table 1. The subjects were not attracted by the sounds generated with the IUS and on the contrary, seemed to perform withdrawal responses rather than approaches.

EXPERIMENT 2—Immediately after Experiment 1 had been completed the sharks were fed live fish that had been damaged by diagonal cuts in the lateral body musculature. Unless the prey fish were damaged, the sharks would not have been able to capture them successfully. After 2 wk during which the subjects fed on live fish exclusively, they were again tested individually.

RESULTS—Table 1 indicates that sharks provided with the stimulation of feeding on live fish after initial deprivation do not respond to mechanically-produced sounds when tested in isolation. There seemed to be no significant improvement in performance with feeding experience even though 1 individual did perform several approach behaviors. These sharks in both Experiments 1 and 2 quite often would swim rapidly around the perimeter of the tank, move with a quick, jerky type of motion, protrude the head out of the water up the side of the tank, or suddenly change speed and direction of swimming in a "startle reaction." I have interpreted this as a sign of distress on the part of the subjects. Because the sharks did not behave this way in the holding tank, it was hypothesized that something associated with the test tank led to these distress responses. An obvious difference between the testing situation and the holding tank was the social environment. Removal of a shark from the holding tank and isolation in the test tank may have been aversive in that the environmental context was changed to such a degree that it produced distress in the sharks and they became unresponsive and/or acted erratically. Accordingly, tests were performed (reported elsewhere) to determine whether a group of 3 sharks provided an optimal social environment for testing purposes.

EXPERIMENT 3—The behavioral responses of groups of 3 sharks were observed over 17 da and differences in performance between trials and control observation periods were noted. The results of these tests are in Table 2. The frequency of the approach-type responses such as IOT, IA and Circles is significantly greater during trials than during control observation periods and further, the approach-type responses taken together occur more frequently than the withdrawal-type responses such as Avoids. Also, there were no instances of the behavior I have come to associate with distress (i.e., rapid, erratic swimming; protrusion of snout up tank walls which occurred in Experiments 1 and 2). It is clear from a comparison of Tables 1 and 2 that the responsiveness of sharks tested in groups of 3 is superior to that of sharks

TABLE 1. Frequency of responses of sharks without species-typical feeding experience tested in isolation.

		EXPERIMENT 1				EXPERIMENT 2			
		Type I Flipper Attached		Type II Flipper Removed		Type I Flipper Attached		Type II Flipper Removed	
	Responses	Trials	Control	Trials	Control	Trials	Control	Trials	Control
Approach	IOT	0	0	0	0	2	0	0	0
	IA	5	0	0	0	7	0	1	0
	Circle	0	0	1	0	7	0	0	0
	Totals	5	0	1	0	16	0	1	0
Withdrawal	Av	22*	3	9	1	1	0	0	0
	N = 78					N = 18			

*p ≤ .025 Differences between trials and control observation periods are significant.

tested in isolation. On 1 occasion the sharks were very excited and rapidly approached, circled the IUS repeatedly and took several bites at the region of the flipper. Similar behavior was reported by Banner (1968) in young lemon sharks presented with broad-band, pulsed noise. While response levels to sounds produced without the flipper were lower than those produced with flipper attached, they were nevertheless greater during trials than control periods (Table 2). Apparently, sounds with large-amplitude hydrodynamic components such as near-field effects and currents are more attractive than sounds without these components.

TABLE 2. Frequency of responses of sharks after feeding on living prey tested in groups of 3.

		Experiment 3			
		Type I Flipper Attached		Type II Flipper Removed	
	Responses	Trials	Control	Trials	Control
Approach	IOT	12	0	1	0
	IA	85	3	28	0
	Circle	34	4	33	0
	Totals	131*	7	62*	0
Withdrawal	Av	93*	0	32*	2
	N = 66				

*$p \leq .025$ Differences between trials and control observation periods are significant.

Analysis of the individual categories of approach responses reveals that the most frequent response to Type I sounds was the IA, followed by Circles and IOT responses. The high IA response frequency contrasts with the low frequency of the IOT category. The significance of this result may be that in most trials, these sounds do not have a level of attractiveness high enough to cause an immediate change in swimming direction upon the first instant of stimulus presentation. However, these sounds may be sufficiently attractive to cause a more gradual increase in response strength later on in the trial so that the animal would subsequently approach to investigate the stimulus more often and with increasing level of arousal. The frequency of Circles tends to substantiate the idea of a moderate level of attractiveness.

The frequency of Av responses to Type 1 sound was the highest of all categories. The apparent contradiction of simultaneous occurrence of high IA and Av responses may be resolved if it can be assumed that an inverted U-shaped function relates attractiveness to stimulus intensity. At distances outside the scoring area, the intensity may be at optimal levels of attractiveness. However, if the shark continues to approach, it may suddenly encounter very high intensity levels which are now no longer attractive and on the contrary produce withdrawal or Av responses. This suggestion is supported by the data for responses to Type II sounds. Here, large amplitude hydrodynamic components are lacking and the IA and Av responses are both lower than with Type I sounds.

Discussion — The sharks in these experiments represent a unique population of subjects. Due to their immediate removal from the uteri of the female, they were deprived of species-typical experience. They were confined in a circular tank and tended to swim in clockwise or counterclockwise paths and occasionally crossed the diameter of the tank. Lemon sharks do not normally swim in this pattern in the wild (Springer, 1950). Also, their feeding experience was limited to the consumption of cut pieces of mullet which were presented daily. Olfactory and visual cues were present due to the fluids emanating from the fish flesh and the light reflected from the cut pieces drifting down from the water surface to the tank bottom.

Auditory stimuli associated with swimming schools of prey fish species; low-frequency sounds of wounded, struggling fish, or sounds of feeding activities of prey species were never experienced by these sharks. They also had never experienced the pursuit of actively swimming, evasive prey species nor the successful seizure and consumption of a struggling victim. Therefore it was not too surprising that these animals were not responsive to the sounds presented in Experiment 1, because these stimuli were unique in their experience. Fuller (1967) has provided a model which may have some bearing on these results.

Fuller's hypothesis which he called the emergence-stress model attempts to account for the disruption of behavior observed when isolates are introduced into the test arena. He stated that "the excessive arousal in an organism exposed to a myriad of unfamiliar stimuli is assumed to produce overload in the neural system underlying many forms of behavior." The experientially-deprived animal presumably becomes habituated to a low level of stimulation and sudden emergence into a condition of high stimulation produces "disrupted" behavior. The level of stimulation in such a situation is influenced by its degree of novelty and its complexity; great novelty and great complexity represent high levels of stimulation. When the responses of non-deprived sharks observed in the pilot study mentioned previously are compared with the naive subjects in the present study, it seems clear that the approach response level of the former is superior. The greater experience of the wild-caught sharks may have reduced the degree of novelty of mechanically-produced sounds to attractive levels.

It is possible that the degree of novelty represented by mechanically-produced sounds is too great to elicit approach responses from experientially deprived sharks. The behavior of the sharks when first presented with live injured fish lends some support to this hypothesis. When the damaged prey were thrown into the tank, the sharks exhibited startle reactions and withdrawal responses and failed to pursue them. After several presentations the sharks did finally respond and begin to pursue the fish but they were not very adept and several injured fish managed to escape. After a few days of practice the sharks became noticeably more expert at capturing injured fish but they never captured an intact fish.

The results of Experiment 2 suggest either (a) that the experiential-maturational factors which have interacted so far were not effective in altering the effects of previous experiential deprivation or (b) there was some aspect of the testing situation that interfered with the subjects' performance. It is possible that the theoretical formulation of Fuller (1967) could be invoked in the present situation but in reverse; that is, the subject becomes habituated to the high level of stimulation (social interaction) which exists in the holding tank and isolation in the test tank would provide such a drop in stimulus level that it represented a stressful condition with consequent "behavioral disruption." The acclimation periods provided in the present experiments (at least 1 hr and sometimes as much as 16 hr) were not effective in overcoming the effects of isolation.

The results of Experiment 3 compare favorably with impressions of the performance of sharks captured in the field with regard to the level of approach responses to mechanically-produced sounds. Also, the performance of sharks when tested as a group was superior to their performance when tested as isolates. It is unlikely that this increase in approach performance could be due to maturational factors alone because only 4 da intervened between Experiments 2 and 3.

It is further unlikely that the effects of only 1 or 2 exposures to the stimuli could have a latent and overwhelmingly positive effect on approach performance. A more likely hypothesis is that the feeding experiences that were provided for the sharks prior to Experiment 2 had a positive effect on approach performance which was revealed when the negative effect of isolation during tests was removed. A corollary hypothesis is that the presence of 2 other sharks along with a subject reduced the disparity in social context between the holding tank environment and the test tank, thus reducing "emergence stress" and its disruptive effects on behavior.

Under the conditions of the present experiment it is not possible to unequivocally assess the effects of experiential factors on responsiveness to sounds due to the confound of social conditions during testing. Further investigations should be initiated in which social conditions are the same in both holding and testing situations and the effect on performance of varying the size of the social group could be measured. Also, if another, larger population of experientially-deprived subjects could be obtained, a between-subjects design with a control group that has no experience with living prey could be incorporated to isolate maturational factors. Of course, testing and rearing would be carried out under optimum social conditions.

SUMMARY—The responses of experientially deprived sharks to low-frequency, irregularly pulsed sounds were measured. Baseline response levels indicated a lack of attraction to these sounds. The sharks were then provided with opportunities to capture living prey and to experience

auditory stimulation associated with wounded, struggling fish. These experiences were not sufficient to overcome the inhibitory effect on responsiveness of social isolation during testing. The social environment provided by 3 sharks tested as a group was associated with superior approach-response performance and stood in marked contrast to performance as isolates. Under the conditions of these experiments it is not possible to distinguish the role of experiential and social factors in the responsiveness to sounds. Suggestions are made for further research to resolve these issues.

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RECENT ADVANCES IN STUDIES OF THE VISUAL SYSTEM OF THE JUVENILE LEMON SHARK (*NEGAPRION BREVIROSTRIS*)

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Abstract: *Due to its phyletic position among the selachians, its relative abundance in Florida coastal waters, and its unusual adaptability to laboratory conditions, the juvenile lemon shark is an excellent model for studies of the sensory biology of the "typical" shark. Our investigations of the physiological optics of this shark's eye have resulted in a mathematical model, or schematic eye, for the species. This optical model is centered around an ellipsoidal lens of high overall equivalent refractive index (1.664) and principal power (140 diopters), and yet all data indicate these animals to be hypermetropic (far-sighted) by about 3 diopters underwater, with no evidence of accommodation. Using the schematic eye, optical limitations on spatial vision of this shark are predictable. In addition to discussing the optics, we briefly review recent findings on the anatomical and functional organization of the retina, as well as psychophysical measurements of absolute visual threshold, in the juvenile lemon shark.*

Throughout the world of vertebrates, there are few major taxa that have been as incorrectly stereotyped as the more than 300 species of sharks. The past portrayals of all sharks as unpredictable, insatiable scavengers have reflected a great deal more about our own misconceptions of these animals than about the sharks themselves. Much of this relative ignorance is attributable to logistical problems of conducting research on living sharks (Gruber and Myrberg, 1977; Nelson, 1978). In addition, sociopsychological prejudices, attached to the label of sharks as maneaters, tend to cloud a general understanding of the biology and behavior of this distinct group of vertebrates.

Contemporary approaches to research on shark biology have fortunately forced advancements in our understanding of these animals. The fields of neural and sensory physiology have played a dominant role in this research, as evidenced by a recent volume devoted entirely to the sensory biology of elasmobranchs (Hodgson and Mathewson, 1978). It is not our aim here to recapitulate the information on the visual systems of sharks contained in this volume (Gruber and Cohen, 1978; Sivak, 1978; Graeber, 1978) or in other contemporary reviews (e.g., Gilbert, 1963; Gruber, 1977), but rather to discuss new findings obtained in our laboratory in Miami between 1978 and 1980. Our objective in this research has been to examine in depth the connecting levels in the visual system of a selected shark species, with the ultimate goal of synthesizing a thorough, quantitative description of this animal's visual world.

The following discussion will be restricted to 3 domains of vision research: (1) physiological optics of the shark eye; (2) anatomy and electrophysiology of the isolated shark retina; and (3) psychophysical determinations of visual sensitivity in living, intact sharks. The first of these research areas is concerned with the eye's capabilities for image formation on the retina, and, ultimately, the limitations imposed by physiological optics on spatial acuity of the shark's visual system. These optical limitations impact upon the task of the retina, which is to transduce the photic stimuli as delivered by the eye's optics into encoded electrochemical signals. This fundamental step in the visual process will be dealt with in the second section, which reports on work conducted by J. L. Cohen in our laboratory. The third section involves behavioral testing at the level of the whole animal to determine absolute visual threshold, which gauges the performance of the entire visual system including optics, retina, and brain. This report of absolute sensitivity represents work conducted by W. Finck in our laboratory.

THE JUVENILE LEMON SHARK—The species of choice for these studies is the lemon shark, *Negaprion brevirostris.* This common inshore shark ranges in the western Atlantic from northern Brazil to North Carolina (Bigelow and Schroeder, 1948), and the juveniles are often the most abundant shark in the shallow coastal waters of Florida Bay and the Florida Keys (Springer, 1950). These animals are particularly well-suited for experimental conditions because of their ability to ventilate the gills and continue to respire during confinement, an unusual trait among shark species.

Another consideration in selecting *Negaprion brevirostris* as a model animal is its phyletic position among the selachians: as a carcharhinid, it is a member of the dominant group of the superorder Galeomorphi, which comprises 73% of all living shark species (Compagno, 1977). Furthermore, as with other carcharhinids, *N. brevirostris* grows to a large size (we recently examined a male measuring 368 cm total length), is predatory from birth, and resides in warm coastal waters, and thus is considered dangerous to man. Out of the 267 cases from the worldwide Shark Attack File (SAF) in which the species of shark could be identified, 6 cases cited a lemon shark as the attacker (Baldridge, 1974).

Due to their year-round availability and practical limitations of the laboratory, only juvenile lemon sharks were utilized in our studies. All of our experimental animals were taken from shallow waters of Florida Bay, in the vicinity of Matecumbe Key in the Florida Keys. Several researchers have previously used juvenile lemon sharks in extensive research on visual function in sharks (e.g., spectral sensitivity, dark adaptation, color vision, nictitating membrane response, pupillary and tapetal response, etc.); thorough reviews of these studies have been made by Gruber (1975, 1977) and Gruber and Cohen (1978).

Reports of field studies of the lemon shark are practically nonexistent; the ecological role of this species in the tropical marine environment is currently under study by Gruber (discussed elsewhere in this volume). Compagno and

Vergara (1978) describe *N. brevirostris* as a benthic species that feeds predominantly on teleosts (catfish, mullets, mojarras) and rays, suggesting that vision could be of comparative importance in the life of this shark.

The eyes of the juvenile lemon shark are mounted laterally on its relatively broad head, with only a small degree of binocular overlap between the 2 monocular visual fields. The lemon shark appears to maintain stability of the retinal image by reciprocal eye movements during swimming, especially during turns. Externally visible features of the eye include an active vertical-slit pupil, which contracts to a thin slit under photopic (bright light) conditions, and dilates to a near-circular aperture under scotopic (dim light) conditions. The nictitating membrane, a feature that the lemon shark shares with other carcharhinids, is a type of third eyelid which can be retracted across the eye in response to physical or chemical irritants, but not normally in response to light (Gruber and Schneiderman, 1975).

PHYSIOLOGICAL OPTICS—To completely understand the optical performance of an eye, the physical nature of its external and intraocular environments must be examined. To do so, investigations in comparative vertebrate optics are typically concerned with determination of the following criteria: (1) a quantitative description of the individual optical components (cornea, lens, aqueous and vitreous humors) in the "average" eye of a given species, including refractive indices of the ocular media, intraocular dimensions, and radii of curvature of refractive surfaces; (2) the animal's refractive state, which refers to the degree of correspondence between the eye's back focal point and the retinal photoreceptors; (3) capability of the species for accommodation, which is the adjustment of the eye's optical power to maintain focus on objects at varying distances from the eye; and (4) the spatial extent of the animal's monocular and binocular visual fields, as determined by eye position and intraocular geometry.

The first of these 4 research areas is the most quantitative but also the most time-consuming, and consequently has been neglected for all but a handful of vertebrate species. And yet, if the variables of this first study area are adequately sampled, a mathematical model of the dioptrics of a species' average eye can be constructed, and this "schematic eye" can subsequently be used to predict and corroborate indirect measurements of the other optical criteria outlined above. It is only by means of a schematic eye that the numerous optical, physiological, and ophthalmological factors involved in the visual process from cornea to retina can be understood (Hughes, 1977).

The only schematic eye developed for a species of fish is that for the goldfish (Charman and Tucker, 1973); none has previously appeared for any elasmobranch species. This omission may be due to earlier characterizations of sharks as being active primarily under scotopic conditions, in which optical factors are relatively minor (see Gruber, 1969). However, with the convincing evidence of photopic visual function in sharks that now exists (Gruber, 1975), we could no longer ignore the dioptrics of the shark eye and still hope to understand overall visual function in these animals.

Sectioning of the eye of the juvenile lemon shark reveals an intraocular organization that is fairly typical of vertebrate eyes. Such a section shows a number of distinctive features (Fig. 1). The sclera is supported by a thick, cartilaginous layer, and the nutritive choroid contains an occlusible tapetum lucidum, whose reflective plates are actively exposed under scotopic conditions. The retina is not vascularized and contains no obvious landmarks other than the optic disc (blind spot), which marks the point of exit of the ganglion cell fibers from the retina. There is no fovea and no centralized retinal *area* has been found [but Walls (1942) quoting Franz claimed that the retina of *Mustelus canis*, also a carcharhinid, possesses an *area centralis*]. The crystalline lens is supported by a dorsal suspensory ligament and the ventral pseudocampanule, said to function as a *protractor lentis* muscle, arising from the ciliary zone; the latter structure has been implicated in possible accommodatory movements of the shark lens (Sivak and Gilbert, 1976). We have not been able to confirm this mechanism in the lemon shark.

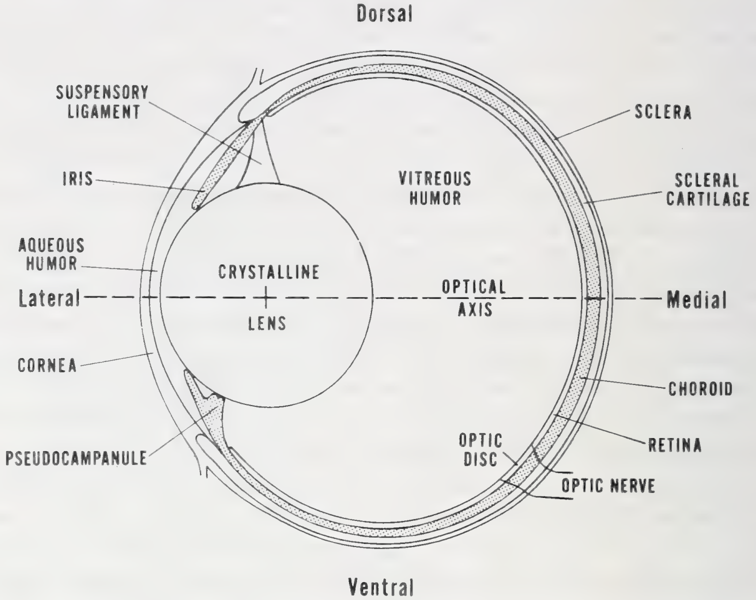

FIG. 1. Diagrammatic transverse section through the shark eye. The lens is ellipsoidal, not perfectly spherical as in the teleost eye. The optical axis is the line passing through the geometric centers of the important refractive surfaces.

From the point of view of physiological optics, the crystalline lens is the most important structure in an aquatic vertebrate eye. This is due to the relative ineffectiveness of the cornea in contributing refractive power underwater. The juvenile lemon shark's lens is not spherical as in teleosts; neither is it "nearly" spherical, as generalized for the elasmobranch lens in the influential writings of Walls (1942). Technically, the lens of *N. brevirostris* is "lenticular" in shape: its dorso-ventral height is, on the average, about 13%

greater than its medio-lateral thickness as measured from frozen sections. This figure falls within the range of values reported by Sivak (1976) for the elasmobranchs *Dasyatis sayi* (18%), *D. sabina* (7.5%), and *Gymnura micrura* (11%). Approximating the elasmobranch lens to a sphere will result in significant errors in a dioptric model of the eye.

The multi-layered cornea of the juvenile lemon shark is markedly flattened compared with the typical aerial cornea, again reflecting its dioptric unimportance. Separating lens and cornea is a relatively narrow anterior chamber, which contains the constantly replenished aqueous humor. The retinal-choroidal boundary, which marks the approximate level of the photoreceptors, is easily distinguishable in frozen sections as a medium contrast border between the dark choroid and the more lateral, lighter retina. The optic disc, the only obvious retinal landmark, is located at angles of about 30° ventral and 10° rostral to the optical axis relative to the lens center; the optical axis is defined as the imaginary line passing through the optical (and geometric) centers of the cornea and lens front and back surfaces. It is this axis on which the cardinal points of the eye's optical system are located.

As previously indicated, the formulation of a mathematical model of an eye's optics is based upon the specification of 3 fundamental variables: refractive indices of the ocular media; intraocular dimensions of the important optical elements; and radii of curvature of the surfaces of those elements (Westheimer, 1972). To derive these as well as other attributes of the schematic eye for the juvenile lemon shark, we have employed a number of optical and anatomical techniques. These include: (1) Abbé refractometry of cornea, aqueous, and vitreous; (2) freezing, sectioning, and photography of excised whole eyes; (3) optical measurement of focal length of the lens in vitro; and (4) retinoscopy and ophthalmoscopy of eyes in living, intact sharks. Various details of these techniques and the resulting data are presented by Hueter (1980) and Hueter and Gruber (1980). Calculating procedures for the schematic eye were derived primarily from Bennett and Francis (1962) and Parrish (1972), and are described by Hueter (1980); these will be discussed elsewhere by Hueter and Gruber (in preparation).

Rather than present these methodological details here, we will discuss the schematic eye model and its implications for visual capability of the juvenile lemon shark within its natural environment. Our results are based on data from 23 lemon sharks (11 males and 12 females, ranging in total length from 60-90 cm) collected in Florida Bay. The mean body size of our experimental animals corresponds to an estimated age of approaching 1 yr from birth (derived from Holden, 1974).

The physical and optical attributes of our schematic eye for the juvenile lemon shark are diagrammed in Fig. 2. The model is centered around a thick, ellipsoidal lens of high overall equivalent refractive index (1.664), resulting in a principal power of about 140 diopters (D) for the lens. (Diopter as a unit of lens power equals the reciprocal of lens focal length in

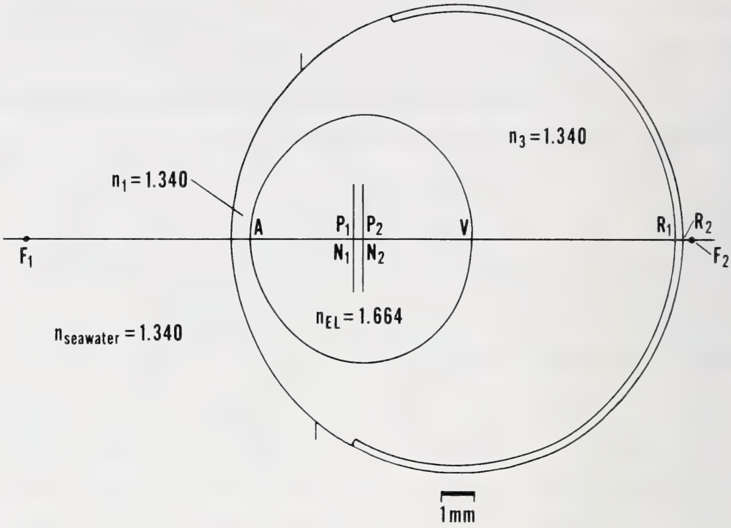

FIG. 2. Schematic eye of the juvenile lemon shark. The crystalline lens is the sole refractive element in seawater. A, lens apex; F_1 and F_2, front and back focal points of the eye; N_1, and N_2, first and second nodal points; n_1 and n_3, refractive indices of aqueous and vitreous humors; n_{EL}, overall refractive index of equivalent homogeneous lens; P_1 and P_2, first and second principal planes; R_1, vitreal-retinal boundary; R_2, retinal-choroidal boundary (photoreceptor layer); V, lens vertex. The principal power of the eye (D_P) is 139.82 diopters; the eye is slightly hypermetropic (by +2.76 diopters) in seawater.

meters, times the refractive index of the post-lens medium.) Apex curvature, and thus dioptric power, is slightly greater than the vertex curvature and power of this lens. The refractive indices of all other optical media, including the cornea, are equivalent to that of seawater (1.340); the lens, therefore, carries the full refractive load in this aquatic eye. The elasmobranch lens is a multi-layered structure of increasing refractive index from periphery to core, an arrangement that reduces the spherical aberration adversely affecting resolution of a homogenous lens. Still, the shark lens can be represented in the schematic eye by a homogenous equivalent lens with a refractive index of 1.664. This substitution incurs a small error in the location of the eye's principal planes, the ultimate effect of which is negligible in the shark schematic eye.

Three pairs of cardinal points (see Fig. 2) are located on the optical axis of the eye's thick-lens system: front and back focal points (F_1 and F_2), first and second principal points (P_1 and P_2), and first and second nodal points (N_1 and N_2). The principal points locate the planes, perpendicular to the optical axis, at which equivalent thin lenses could be substituted to represent the eye's entire optical system. Such thin lenses would have a principal focal length (f_P) equal to the distance $\overline{P_2F_2}$ ($= \overline{F_1P_1}$); this distance is 9.583 mm in the juvenile lemon shark, and thus the principal power (D_P) of the eye is 139.82 D.

Because the refractive indices of the pre- and post-lens media are equal (1.340) in this eye, the system is termed symmetric or equifocal, and the first and second nodal points are thus coincident with the principal points (Bennett and Francis, 1962). The nodal points represent the "optical pivots" of the eye: a light ray directed toward the first nodal point will appear to emerge from the second nodal point along the same angle of incidence. These points, therefore, are essential in specifying visual angle and image size in the eye, 2 of the more important variables affecting the spatial characteristics of the retinal image.

The separation between the second nodal point and the photoreceptor layer ($\overline{N_2R_2}$) is 9.398 mm in the juvenile lemon shark. Using simple geometric relationships, we conclude that each degree of visual angle, as specified by object size and distance from the eye's first nodal point, is represented by a subtense of 0.164 mm on the retina; a 1 mm retinal image would conversely correspond to an object occupying a visual angle of 6.09°. This attribute is commonly expressed as retinal magnification factor (RMF) in terms of mm/°visual angle (Hughes, 1977) or μm/°visual angle (Easter et al., 1977) at the photoreceptor layer. RMF for the juvenile lemon shark is therefore 0.164 mm/°, or 164 μm/°visual angle; this value equals (25.7 x lens thickness) μm/°mm, where lens thickness ($\overline{AV}$) is 6.381 mm. In comparison, the goldfish RMF equals (20.5 x lens thickness) μm/°mm, or about 60 μm/° (Easter et al., 1977); the bottlenosed dolphin RMF is approximately 240 μm/°, or about (25.0 x lens thickness) μm/°mm (derived from Dawson et al., 1972). Thus, the factor relating RMF to lens thickness is comparable for the lemon shark (25.7), the goldfish (20.5), and the dolphin (25.0). Differences in absolute retinal magnification in these 3 aquatic species of very different phyletic origins are primarily due to simple differences in ocular size, and not to major divergences in optical design.

Though the thick lens of the juvenile lemon shark produces nearly 140 D of dioptric power (compared to only about 20 D in the human lens, for example), all of our data indicate that this power falls short of that required to correctly focus the image onto the photoreceptors. The amount of this ocular refractive error (K), or dioptric mismatch between the back focal point (F_2) and the photoreceptors (R_2), is +2.76 D underwater as calculated from the schematic model; this condition is termed hypermetropia, or farsightedness, and is precisely the same condition that forces many persons to wear convex lens spectacles to see close objects in focus. Hypermetropia in the lemon shark is corroborated by measurements on living animals using the technique of retinoscopy, a nonverbal method developed by ophthalmologists to determine refractive error in humans. Furthermore, it seems that the retinoscopically measured hypermetropia of adult lemon sharks is even greater than that of the juveniles (Spielman and Gruber, in preparation).

The out-of-focus distance ($\overline{R_2F_2}$) is only 185 μm, which appears to be very small, but the results of a paired-sample t-test (Zar, 1974) rejected the null hypothesis of no difference between the principal focal length and the second principal plane-to-photoreceptors distance ($.01 < P < .025$). The positive refractive error is therefore statistically significant—but what is its visual importance?

A condition of hypermetropia, in which the back focal point of the eye lies behind the photoreceptors, signifies that no object can be sharply imaged on the retina without some type of accommodatory adjustment; the nearer an object is to the hypermetropic eye, the more blurred its image becomes in the absence of accommodation. Since we have not been able to demonstrate the presence of any dynamic or static mechanism for accommodation in the juvenile lemon shark, the potential disruptive influence of the hypermetropia on this animal's visual acuity must be given serious consideration.

Visual acuity is a general term that refers to an animal's ability to distinguish between 2 points or contours under specified conditions of illumination. Acuity is not a concrete specification of a visual system, but rather is an operationally defined feature of an animal's behavior that varies with the conditions under which it is measured, because it is determined by optical as well as neural factors (Hughes, 1977). With the aid of the schematic model, however, certain types of visual acuity can be estimated solely on the basis of the morphological design of the eye. Excluding the incorporation of the photoreceptors, this analysis omits the contributions of neural factors, concentrating instead on optical limitations in the assumption that the neural processing cannot reconstruct an optically degraded image.

Hypermetropia certainly contributes to image degradation. Because the back focal point lies behind the retina, each point source in visual space is represented not by a corresponding focused point in the retinal image, but rather by a blur circle. The extent of this blur in the horizontal meridian is 19.3 μm on the lemon shark retina, or 7.1′ of retinal subtense representing each singular point in visual space. These numbers apply to the best of conditions when pupillary size is minimal under photopic illumination; with a more dilated pupil, the blur increases.

Whether or not the 7.1′ blur circle is perceived by the shark, however, depends upon the resolving power of the retinal mosaic. If the photoreceptor grain is in fact so large that the point blur falls between adjacent receptors, the animal will not be able to detect an improvement in image clarity with the correction of its refractive error. Thus, the density of those receptors probably responsible for photopic, high acuity vision—the cones—must be examined before we can assess the significance of the lemon shark's hypermetropia.

Using the data from Gruber et al. (1963), we estimate the average cone density in the fixed retina of the juvenile lemon shark to be roughly 28 cones per 2000 μm^2 or 14,000 cones/mm^2. Since there is no known heterogeneity in cone density throughout the lemon shark retina, and since no evidence of any double or twin cones has been reported for any elasmobranch species

(Gruber and Cohen, 1978), this number can be used to calculate the average distance between retinal cones. Accounting for shrinkage during histological preparation, we estimate the average intercone separation to be 11.3 μm in the lemon shark by use of a formula developed by Northmore and Dvorak (1979). Their formula furthermore incorporates the retinal magnification factor of an eye to yield a minimum separable angle (MSA); this value is 4.1′ in the juvenile lemon shark. Calculations were based on the dimensions given above and in Fig. 2.

The idea that retinal resolving power, and ultimately visual acuity, may be limited by the distance between adjacent cones is attributed to von Helmholtz (1924). Recent psychophysical studies on a variety of teleosts have consistently shown that these species can discriminate visual targets down to threshold angles that agree quite well with the MSA predicted from the morphological data (Northmore et al., 1978). It is of value, therefore, to compare the juvenile lemon shark MSA of 4.1′ with those of other fishes.

Tamura (1957) and Tamura and Wisby (1963) calculated MSAs for a number of engybenthic ("littoral") and epineritic ("pelagic") species of marine teleosts inhabiting continental shelf waters. Though their calculations suffer from a few inaccuracies (Northmore and Dvorak, 1979; Sadler, 1973), their data can be adjusted and utilized for purposes of comparison. This adjustment reveals that the MSAs of most of the engybenthic teleosts studied by Tamura (1957), such as tetraodontids, serranids, sparids, and scorpaenids, are comparable to the 4.1′ MSA of the juvenile lemon shark, also an engybenthic animal. On the other hand, the 10 large epineritic species studied by Tamura and Wisby (1963), including dolphin (*Coryphaena hippurus*), three species of tunas (*Euthynnus* and *Thunnus* spp.), white marlin (*Tetrapturus albidus*), and great barracuda (*Sphyraena barracuda*), all display MSAs less than that of the lemon shark, i.e., from 0.9 to 2.1′ of visual angle. Though this is in part due to larger eye size, most of the 10 epineritic teleosts also have specialized retinal areas with higher cone densities than that of the lemon shark.

Thus, some general trends in the physiological ecology of spatial vision in these aquatic vertebrates begin to emerge. The potential acuity of the juvenile lemon shark is comparable to that of teleost fishes with similar ecological niches, i.e., feeding on or close to the bottom, in nearshore waters that are subject to periodic high turbidity. This is particularly true of our population of experimental animals from Florida Bay: throughout the bay, steady winds are sufficient to turn the water so turbid that the bottom is not visible from the surface in depths of only 1.8 m (Ginsburg, 1956). Under average conditions, the water is characteristically a "translucent milky-green color" (Enos and Perkins, 1979: p. 61). In contrast, the scant data on the potential acuity of teleosts inhabiting more pelagic zones (tunas, billfishes, etc.) suggest that the spatial resolving power of these species' eyes is comparatively higher. These fast swimming, predatory fishes generally function in a clear visual environment that is wide in range, completely uniform, and devoid of detail; in such an environment, the detection of the slightest disruption in the topographic uniformity of the visual field would seem to be highly desirable.

For the engybenthic animal, such as the juvenile lemon shark, the baseline visual environment already presents detail, much of which is irrelevant visual stimulus; in addition, the environment provides poor photic transmission of those details. These conditions imply that investigation of every feature in this visual environment would be an inefficient use of time. In these animals, therefore, it may not be the spatial organization of fine detail that is monitored, but rather the coarse, high contrast changes in the photic environment. Such a strategy might lead to the evolutionary development of: (1) a noncentralized, rod-dominated retina; (2) a de-emphasis of accommodatory capabilities; (3) a reduction in the forces selecting for emmetropic optics (zero refractive error); and (4) greater use of spatial information from senses other than the visual system (i.e., acousticolateralis, electroreceptive, chemoreceptive, etc.). Such adaptations perhaps characterize the juvenile lemon shark.

As to this shark's far-sightedness, a comparison of the potential MSA of 4.1′ with the minimal hypermetropic blur of 7.1′ reveals that the calculated refractive error can significantly affect resolution. The actual degree of this impairment is difficult to assess in the absence of further physiological data, such as Rayleigh criteria and Weber-Fechner fractions. Preliminary estimates, however, suggest that the +2.76 D hypermetropia could limit the juvenile lemon shark to a visual acuity threshold as high as 12.4′, which represents one-third of the potential resolving power of its retinal mosaic. But considering the poor optical quality of this animal's environment, perhaps it is too much to expect the refractive states of these sharks to fall near emmetropia. Furthermore, we must keep in perspective the qualitative difference between the disadvantages of functioning as a +2.76 D human hypermetrope vs. a +2.76 D hypermetropic shark. Given the murky visual environment of habitats such as Florida Bay, it wouldn't be surprising to find that reduction of the juvenile lemon shark's far-sightedness would lead to no significant improvement in this animal's functional acuity.

Retinal Anatomy and Electrophysiology—It should be evident that much of the preceding discussion borrows heavily from our knowledge of the shark retina. Although the eye's optics are essential in organizing light stimuli into an orderly topographic format, possibly nowhere in the entire visual system is the processing of photic information more critical than in the retina. It is in this 200 μm-thick tissue of interconnecting neurons and supporting elements that the information contained in light quanta is first transduced into electrochemical potentials, within the photoreceptor outer segments. After signal processing by several interneurons (horizontals, bipolars, amacrines, and perhaps other poorly known cells such as interplexiforms), the visual information is organized into its final retinal form by third-order neurons known as retinal ganglion cells. These transmit to the visual centers of the brain.

Previous studies utilizing light microscopy on the retina of the lemon shark (Gruber et al., 1963) have demonstrated the presence of the 2, morphologically distinct classes of photoreceptors which typify most vertebrate retinas. These are the rods, which are said to act primarily at low light levels and provide achromatic vision, and the cones, thought to be active at higher light levels and to encode for color vision. It was necessary, however, to demonstrate this morphological segregation in the shark retina at the ultrastructural level, using the electron microscope to examine the further fine details differentiating vertebrate rods from cones. This has now been accomplished in our laboratory, and the results have been described by Cohen (1980). One such detail involves the plasma membrane of the photoreceptors. As is consistent with photoreceptor morphology in other duplex retinas, the outer segment discs of the lemon shark rods are completely enclosed by the plasma membrane, whereas the discs of the cones are continuous with the membrane and are therefore open to the extracellular or ventricular space (Gruber, 1975; Cohen, 1980). Thus, an anatomical basis for color vision in the lemon shark has been firmly established.

With the ultrastructural confirmation of cones, light microscopy was subsequently used to survey the relative densities of rods and cones across the lemon shark retina. As mentioned earlier, no centralized region of high cone density has been found. However, a greater proportion of cones than previously believed, i.e., 5 rods to each cone, rather than the relatively homogeneous 12:1 ratio first reported by Gruber et al. (1963), has been found in the dorsal part of the lemon shark retina. This is an interesting result, as it indicates retinal specialization for the ventral visual field, which would be advantageous to an engybenthic predator feeding on benthic teleosts, rays, and invertebrates.

As previously noted, responses of the rods and cones to light stimuli are ultimately received by the ganglion cells, the axons of which leave the retina to form the optic nerve. Based on thin sections stained for light microscopy, Cohen (1980) has described 2 classes of ganglion cells in the lemon shark retina: cells of regular size (approximately 8-10 μm in dia), and giant ganglion cells ranging from 20-30 μm in dia. Extracellular recordings from the ganglion cells of the isolated shark retina have revealed a range of responses to various photic stimuli. The spatial extent of the retina over which a single ganglion cells responds, i.e., the cell's receptive field, ranges from 0.85-1.45 mm of retinal subtense; with a retinal magnification factor of 0.164 mm/°, these receptive fields correspond to visual angles of between 5.2 and 8.8°. Such large receptive fields (also found in teleosts) are indicative of the high convergence of photoreceptors onto ganglion cells in this rod-dominated retina. Compared with the MSA prediction of 4.1 min of arc from the photoreceptor mosaic, the receptive field sizes of the ganglion cells are approximately 2 orders of magnitude larger. This is consistent with results obtained from other vertebrate retinas. A number of explanations have been proposed to account for the curious fact that visual acuity of an animal corresponds more closely with its photoreceptor organization rather than with the receptive field sizes of its ganglion cells. These explanations include the possibilities of overlapping receptive fields or subunits within single receptive fields (Northmore et al., 1978).

Spectral sensitivity of the lemon shark ganglion cells has revealed that those cells responding to the offset of a light stimulus occur in 2 classes: 1 class has input from only 1 type of cone, with a peak spectral sensitivity around 544 nm; the second class responds at lower thresholds than the first and apparently receives input from both cones and rods, with a λ_{max} located around 520 nm. This kind of duplex input has also been found for those ganglion cells responding to the onset of light. In no case has a pure rod spectral sensitivity ($\lambda_{max} = 501$ nm) been found for a dark-adapted ganglion cell in the lemon shark retina, suggesting that both rods and cones contribute input under scotopic conditions. Such a conclusion, also reported for other vertebrate retinas, would signify that the clear-cut dichotomy in function postulated for vertebrate photoreceptors requires reconsideration.

Visual Psychophysics—The combined performances of optics, retina, and brain are ultimately responsible for the overall efficacy of the visual system, which is best evaluated through psychophysical measures of visually mediated behaviors. With structures such as a widely dilating pupil, a large lens, a rod-dominated retina, ganglion cells with wide receptive fields, and a tapetum, the juvenile lemon shark is well-equipped for vision in dim as well as bright light. At the lower end of the range, the minimum photic energy that a dark-adapted animal requires to detect a visual stimulus represents its absolute sensitivity, and this attribute for the lemon shark has recently been behaviorally measured in our laboratory (Finck, 1980).

In these studies, 3 juvenile lemon sharks were tested using a classical conditioning paradigm to determine their absolute visual threshold for a 12° circular photic stimulus. Based upon the results of the retinal physiology studies, light with a wavelength of 520 nm was used to test the dark-adapted animals. The behavioral response elicited when the shark detected the light was a conditioned movement of the nictitating membrane (Gruber and Schneiderman, 1975).

The absolute threshold, as calculated from the stimulus irradiance which allowed 50% correct responses over 29 sessions of 70 trials each, was 5.8×10^{-6} $\mu W/cm^2$ measured at the shark's cornea. When dark-adapted human subjects were tested under the same conditions at 520 nm, their absolute sensitivity averaged about one log unit more sensitive than the sharks. These results conflict with previous measurements by Gruber (1969). In that study, binocular viewing and white light were used to determine that the absolute sensitivity of the juvenile lemon shark was 0.25 to 0.5 log unit more sensitive than that of human subjects tested on the same adaptometer.

This inconsistency may be due to methodological differences, or to unexplained factors related to spectral sensitivity of the lemon shark. In any case, it is apparent that many more behavioral studies are required to understand the visual capabilities of these sharks under both scotopic and photopic conditions.

CONCLUDING REMARKS—The preceding discussion is by no means intended to present a complete picture of the visual capabilities of sharks. From the standpoint of spatial vision, for example, we know very little about the topographic projection of the retinal images onto the optic tectum, the primary visual center in the shark brain. Research exploring this link in the visual system—that is, what the shark's eye tells the shark's brain—will be required before we can attempt the leap from speculation to explanation of the visual experience of a given shark species.

Our purpose in this review, therefore, has been to present the results of some current and ongoing studies on the visual systems of sharks, utilizing the juvenile lemon shark as a model animal. Though a large body of quantitative information on elasmobranch biology, particularly in the area of sensory physiology, has amassed in the last 2 decades, wide gaps still exist in our understanding of the factors that shape shark behavior and ecology. It can no longer be claimed, however, that sharks as a group are unpredictable, for unpredictability usually springs from unfamiliarity. As we gain a broader understanding of the mechanisms underlying the biology of these animals, their behavioral patterns will doubtless become more and more predictable, though we dare say not boringly so.

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CYCLICAL PATTERNS OF FOOD INTAKE IN THE LEMON SHARK *NEGAPRION BREVIROSTRIS* UNDER CONTROLLED CONDITIONS

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ABSTRACT: *Food intake of lemon sharks was investigated to determine whether hunger and satiation play a role in their behavior. Lemon sharks* (Negaprion brevirostris) *were placed under controlled conditions and given a single 45 min feeding trial each day for 95 da. During a trial the sharks were offered preweighed pieces of fish fillet and rate of feeding was individually monitored. A spectral analysis of the intake data revealed a tendency toward 4-day cycles in amount eaten. We suggest that the 4-da cycle reflects an internally mediated biological rhythm. Thus, appetite varies over time and satiation certainly operates in the behavior of lemon sharks.*

ONE of the major techniques for control of motivation in learning studies is the use of food as a reinforcer for appropriate behavior (Kling and Riggs, 1971). However, before such studies can be undertaken, the experimenter must understand the baseline rate of food intake, or the so-called *ad libitum* rate of feeding of the subject species. This is because food intake varies over time, and thus the behavior of an animal will be influenced by how hungry it is at the time of the task. For example, food used as a reinforcing stimulus overrides most other motivational rewards, except when the animal is sated. However, the simplicity and ease of food deprivation to control hunger has made food reinforcement the technique of choice in thousands of learning studies (Kling and Riggs, 1971).

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Many studies have examined food intake under controlled conditions using the rat as an experimental subject (Sheffield, Roby and Campbell, 1954). Yet, no such baseline studies have been performed on sharks even though they have been used as subjects in at least half a dozen conditioning experiments (Clark, 1959; Aronson, Aronson and Clark, 1967; Graeber and Ebbesson, 1972; Gruber and Myrberg, 1977). Graeber (1974) examined food intake in sharks, but the interpretation of his results was complicated by uncontrolled variables because his subjects (lemon sharks) were held in outdoor pools. To rule out possible effects of variation in temperature, salinity, etc., we have replicated Graeber's (1974) study, but under controlled conditions. The final objective of this study is to establish the rate of food intake over time and to determine if that rate varies systematically.

Materials and Methods—The species used was the lemon shark, *Negaprion brevirostris.* Two males and 4 females, averaging 69.7 cm in total length and 1745 g in weight were the subjects. All 6 sharks were captured in Florida Bay by a commercial collector. The specimens were transported to the study site in plastic bags inflated with oxygen. At the study site, the sharks were kept in a 6000 l recirculating seawater aquarium, with as many as 15 other sharks. After being maintained several weeks, their activities appeared normal, and we assumed that they had recovered from the trauma of capture. At this time, each shark was individually marked, weighed on a balance, sexed and measured.

The next day they were given an antihelminth bath; 2 da later each shark was given a multivitamin-mineral formulation (Vigran-Squibb), and the next day the experiment began. At the end of the experiment 95 da later, each shark was again weighed and measured.

Two lemon sharks were each placed in 3 recirculating seawater tanks. One of the tanks was 1.2 x 1.2 x 0.45 m, with a total volume of 650 l and flow rate of 25 l/min. In this tank, fluorescent light was supplied for 8 hr on weekdays and 2 hr on weekends. Another system containing 2 tanks of 1.8 x 1.2 x 0.15 m had a total volume of 650 l and a flow rate of 18 l/min. In this system fluorescent lights controlled by mechanical timers provided light for 10 hr each day. Thermostatically-controlled aquarium heaters kept the temperature in both systems at 25 ± 2°C. Distilled water was added to each tank as needed to maintain salinity at $31 \pm 2^{\circ}/_{00}$. Details of the aquarium system and its controls are in Gruber (1980).

Examination of the relations of food intake to levels of salinity, light, and temperature by analysis of variance (Meyers, 1979) showed there was no significant relationship between any of these environmental conditions and food intake (Table 1). Therefore, within the limited range of variability in our study, none of these environmental variables affected food intake. Thus, background conditions which we evaluated were held constant.

The food used throughout the study was jack cravalle (*Caranx hippos).* Each fish was cut into 10 g (wet weight) boneless fillets. All the sharks were allowed to consume as much fish as required to satiate them. Feeding times

TABLE 1. Relation between food intake and environmental factors.

Test	Salinity	Temperature	Light
Cross Spectral Analysis	No correlation	No correlation	No correlation
Analysis of Variance	F (2,91) = 1.925 ns	F (3,91) = 2.383 ns	-
T-test	-	-	t (89) = .4205 ns

ns = not significant at 0.05 level.

were between 1500 hr and 1800 hr daily for 95 da. During the feeding period each piece of fish was dropped into the tank in front of an oncoming shark. Once the shark swallowed the piece, another was dropped into the tank. This continued until each shark refused to eat. Then after 15 min the procedure was repeated. The amount consumed during the 2 daily trials was recorded as grams eaten per day for each of the 6 sharks. This was not *ad libitum* feeding. *Ad libitum* feeding requires that food be left in the tank continuously. This was not practical because food remaining in the tank quickly spoils causing a bacterial bloom. Such a bloom will deplete dissolved oxygen thus suffocating any sharks in the tank. However, Valle and Nikaido (1976) reported that under a variety of conditions, single-meal-fed rats gain weight at the same rate as *ad libitum* nibblers.

A pilot study lasting 29 da preceded the main study. Three lemon sharks were placed in the same tanks as described under much the same conditions and were fed in the same manner.

RESULTS—The food intake record for each of the 9 subjects was examined to evaluate any cyclical patterns in feeding. One way to search for such patterns is to plot food intake over time and visually observe any regular changes in amplitude. This was the method used by Graeber (1974). However, subjective methods of detecting rhythms are extremely unreliable because even randomly-generated time series may appear to be rhythmic (Jaffe, Breskin and Gerstman, 1972). Conversely, a tendency toward periodicity may be difficult to detect by visual examination if it is obscured by random changes in amplitude or phase (Luce, 1970).

The food intake record of shark #12 is in Fig. 1. While subjective visual examination shows substantial variation in daily food intake, it does not reveal any periodicity. However, many biological oscillations are not perfectly periodic; cycle length and amplitude can vary greatly. Therefore, an objective technique is needed that can detect periodicities masked by random variation. Spectral analysis (Chatfield, 1975) fulfills this requirement.

Spectral analysis was derived from an early statistical technique called periodogram analysis (Box and Jenkins, 1970). Periodogram analysis is a procedure for partitioning the variance of a time series into the amounts or

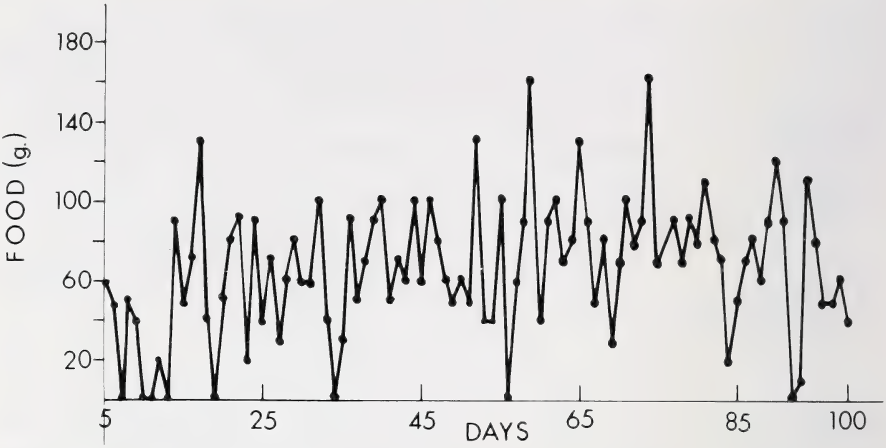

FIG. 1. Food intake of lemon shark *(Negaprion brevirostris)* #12 over 95 da of captivity. The shark was held in a 600 l recirculating aquarium under constant conditions and fed to station daily. While food intake varied considerably over time no particular periodicity was evident from the unanalysed feeding record.

portion of variance accounted for by each of a set of periodic components. The null hypothesis is that the data are aperiodic (i.e., the variance is equally divided among the periodic components). When a periodic component accounts for a much larger share of the variance than other components, this indicates a tendency toward regular cycles in the data. Spectral analysis includes additional smoothing and averaging techniques to obtain more reliable estimates of the variance accounted for by each component, but it provides essentially the same information as periodogram analysis.

Spectral analysis was performed on our data using the Biomed Program BMDO2T (Dixon, 1970). In this program the user determines the set of equally-spaced frequencies by choosing a maximum lag m. The set of frequencies then includes $\frac{i}{2m}$ for i = 1, 2, .. m. Chatfield (1975) suggests that the maximum cycle length 2m should be no more than one-third of the total number of observations. We selected m = 14; which included cycle lengths ranging from 2 to 28 da. Other interesting cycle lengths such as 4, 7, and Graeber's 15 da cycle were included in our set of periodic components.

In this study we began by choosing several different maximum cycle lengths, so that we included as many different frequencies as possible for an exploratory analysis. Examination of these results suggested that 4, 7, and 28 da cycles were most common. The choice of m = 14 (maximum cycle of 28 da) produced the clearest pattern of results, and for this reason it was used for the final data analysis reported herein. Choosing m = 14 did not result in the masking of any periodicities that were evident when other cycle lengths were used, nor did it introduce periodicities that were absent using other values of m.

Given a set of frequencies based on m and the food intake record for a single animal, the Biomed Program produces a spectral estimate for each frequency. As noted, a large spectral estimate indicates periodicity, yet the Biomed Program does not provide tests of statistical significance to evaluate which spectral estimates are significantly larger than expected. However, Shimshoni (1971) provided procedures for evaluating the size of periodogram estimates which we have applied to our spectral estimates. To get a clearer idea of the size of the spectral estimate in a power spectrum, each spectral estimate may be divided by the sum of the spectral estimate (i.e., it is transformed into a percent of the total). If the variance were equally distributed over the 14 periodic components then one would expect each component to account for .071 (1/14) of the total. Comparison of the transformed spectral estimates with this expected value of .071 makes it easy to identify any periodic component that accounts for a greater than expected share of the variance. The transformed power spectra for several subjects can be averaged together, because the transformation into % variance puts all the spectra into the same scale. This transformed power spectrum is similar to the spectral density function (Jenkins and Watts, 1968).

Table 2 shows spectral estimates for all 8 sharks transformed as described into % of power spectrum at each frequency. The right hand column shows the average power for all 8 sharks. Note the highest percentages at 7 and 3.5 to 4 da. These mean percentages do not greatly exceed the expected value of .071. However, most of the 8 sharks constantly exceeded the expected value of the 7 and 4 da cycles.

The mean power spectrum (averaged across all the sharks) from Table 2 is in Fig. 2. Conspicuous features of this plot include peaks at 7 and 4 da. Individual animals had power spectra similar to this average; the clearest example was that of shark #12 shown in Fig. 3. Yet, there was variability among subjects: some even lacked the 7 or 4 da peak (Table 2).

Some obvious differences were noted between the main and pilot studies. The 7-da peaks so clear in the main study were absent in the pilot study. Also, 28-da cycles were indicated in the main study, but pilot study lasted less than 28 da and so insufficient data were available to make a comparison of the 28-da period.

Some findings were consistent across the pilot and main study. The 4-da cycle was clearly indicated in both studies. Yet, there were exceptions; shark #14 displayed 7-da cycles, but lacked 4-da cycles. Shark #01 also lacked 4-da cycles but had a peak at 4.7 da. Such results indicate that the 4-da cycle was not universal in our shark population.

Discussion—The results of the Power Spectral Analysis across the 562 data points included in the study are consistent enough to justify the following inferences: (1) most animals showed a tendency toward regular 3 to 4 da cycles in food intake, both in the pilot study and the main study; (2) 2.5, 7, and 28-da cycles also appeared in the food intake for a few animals; however, these were much less consistent than the 4-da cycles. Because en-

TABLE 2. Percent of power at each frequency.

		Pilot Study			Main Study					
Frequency	Period 1/f	Shark 01	Shark 02	Shark 03	Shark 10	Shark 11	Shark 12	Shark 13	Shark 14	Average of all Sharks
.036	28	----	----	----	.108	.077	.115	.169	.088	.111
.071	14	.079	.089	.126	.089	.014	.016	.038	.106	.070
.107	9.3	.068	.087	.084	.074	.065	.086	.049	.152	.083
.143	7	.038	.068	.041	.109	.105	.102	.094	.132	.086
.179	5.6	.071	.062	.043	.094	.069	.046	.089	.064	.067
.214	4.7	.103	.036	.081	.069	.071	.058	.063	.044	.066
.250	4	.070	.117	.145	.075	.116	.116	.091	.054	.098
.286	3.5	.071	.144	.126	.073	.117	.112	.077	.048	.096
.321	3.1	.124	.044	.029	.064	.082	.094	.057	.029	.065
.357	2.8	.169	.032	.063	.047	.054	.063	.054	.044	.066
.393	2.5	.114	.091	.093	.032	.062	.038	.029	.057	.064
.429	2.3	.041	.149	.079	.038	.059	.044	.048	.059	.064
.464	2.2	.029	.068	.039	.059	.052	.054	.074	.059	.054
.500	2	.021	.008	.036	.069	.057	.058	.068	.064	.048

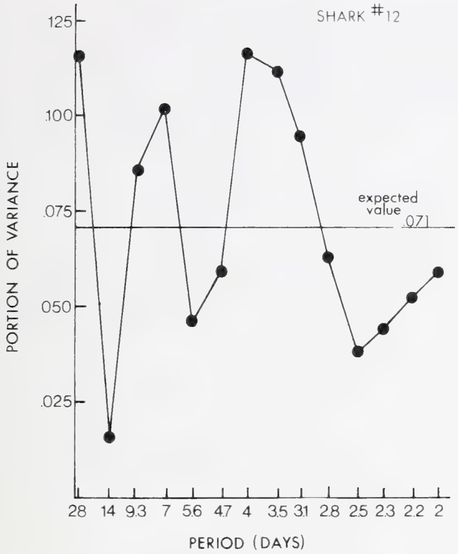

FIG. 2. Standardized power spectrum for data shown in Fig. 1. Peaks represent periodicities in food intake at 28, 7 and 4 da.

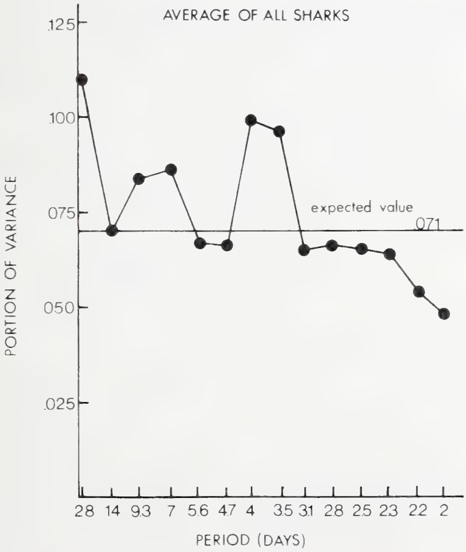

FIG. 3. Standardized average power spectra for all 8 lemon sharks. As in Fig. 2, periodic components were seen at 28, 7 and 4 da. The 28-da peak is from the 5 sharks of the main study because the pilot study did not last long enough to record food intake at day 28.

vironmental parameters were relatively well-controlled, and (statistical) analysis showed no association between these variables and food intake, it is unlikely that the 3-to-4-day cycles observed in this study are artifacts dependent upon periodic changes in salinity, temperature, or light levels.

There were 4 periodicities of interest: 28, 15, 7 and 4 da. No firm conclusions about the existence of 28-da cycles could be drawn because the experiment only included 4 repetitions of this cycle. By most standards this is the absolute minimum quantity of information (Chatfield, 1975); a longer data record is needed. We have noted that lemon sharks in the field tend to feed on rising tides. This implies a possible tidal or lunar input to their feeding behavior. So the 28-da cycle may be a genuine effect and should be carefully considered in further studies.

Graeber (1974) suggested that the rate of food intake of the lemon shark peaks every 15 da. Four of our sharks have above average spectral estimates at 14 da; however, this was not a consistent feature of the data. Thus, our results did not replicate Graeber's findings that 15-da cycles are the most conspicuous feature of food intake.

The overall environmental conditions in the laboratory differed somewhat on weekdays and weekends. Therefore, we cannot be sure that the 7-da cycles observed in the main study were not merely artifacts. The environmental conditions of the pilot study were also somewhat different from the main study. Because the 7-da cycles were absent in the pilot data, they may even be due to environmental cues characteristic of the main study only.

On the other hand, 4-da cycles were very clear for 5 subjects; marginal for 2 and absent in 1 subject. However, these 4-da cycles did appear in both the pilot and main studies. Our 95 da record includes up to 24 repetitions of this cycle for each shark, which strengthens our impression that these 4-da cycles are real and consistent.

Because we were unable to identify any environmental cues in the laboratory with a period of 4-da, we assume that the 4-da cycle of feeding behavior is internally generated. Additionally, we are not aware of any 4-da environmental cycles in the field which would entrain such behavior. Thus, the adaptive value of such a 4-da cycle is not readily apparent. We suggest 2 possible explanations. One concerns the synchrony of social behavior; the 4-da cycle may provide the basis for social entrainment. Another possibility is that in the field these sharks operate on a "feast or famine" schedule, similar to other predators (Schaller, 1972). Re-examination of Fig. 1a indicates that the typical cycle consists of a gradual 2-3 day rise, to a peak intake, followed by a sharp drop in food intake. Graeber (1974) also found a sharp drop in food intake following the peak. This suggests that after the animal is sated, it takes a few days for the appetite to become re-established.

In conclusion, we have shown that the food intake of captive lemon sharks is subjected to substantial but periodic variation over time; we have also shown that these sharks can be fed to satiation and refuse to consume more food until some time has passed. Therefore hunger and satiation probably play a role in the shark's food intake behavior.

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A HYPOTHALAMIC FEEDING AREA IN THE BRAINS OF SHARKS AND TELEOSTS

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Abstract: *Recent findings in teleosts indicate that an area of the hypothalamus (subglomerular area and periventricular zone of the inferior lobe) is involved in the regulation of feeding. The results are based on experiments utilizing brain stimulation, lesion and recording techniques. At least in goldfish, neurons in this area are preferentially activated by olfactory and gustatory input. Comparative anatomical studies suggest that a similar and probably homologous area is present in the shark hypothalamus and feeding activity has been elicited by electrical stimulation of this area in free-swimming nurse sharks. Although the direct evidence in elasmobranchs is still meager, it seems likely that the shark inferior lobe is also involved in the control of feeding. The indication from studies in teleosts, that this region is sensitive to olfactory stimuli, is consistent with frequent observations that many sharks and teleosts can be strongly aroused to feed in response to certain chemical stimuli.*

Studies carried out over the past several years have begun to define the neurological substrates underlying feeding behavior in fishes (see reviews by Peter, 1979 and Demski, 1981). Most of the work has been on teleosts, primarily because of their widespread availability and ease of maintenance; however, some experiments have been performed on a few elasmobranchs despite the relative difficulty of using them as subjects. I present evidence that an area of the inferior lobe of the hypothalamus is involved in the control of feeding on both teleosts and sharks. An initial review of behavioral, physiological and anatomical findings is followed by a discussion of the structural basis for considering feeding areas in the inferior lobes of sharks and bony fishes as probable homologs.

Experimental evidence for hypothalamic feeding mechanisms in fishes — Based on early anatomical studies, Herrick (1905) suggested that the inferior lobe of the hypothalamus was involved in the control of feeding in teleosts. He stressed the importance of the area as an integrating center for chemical and perhaps other sensory inputs and also described several output pathways to motor systems through which the area could potentially mediate feeding responses. Herrick's conclusion that the inferior lobe was involved in the sensory analysis of food objects was later restated by Ariëns Kappers, Huber and Crosby (1936) in their classic 3 volume treatise on the comparative neuranatomy of vertebrates.

The first direct experimental evidence in support of Herrick's hypothesis came from studies in which areas of the brain were stimulated electrically in free-swimming teleosts. Consistent feeding activity was evoked by stimulation in the vicinity of the lateral recess of the third ventricle in the inferior lobe (Fig. 1), with perhaps the most sensitive region being in the dorsal part of the lobe (subglomerular area of Savage and Roberts, 1975). So far, feeding responses have been triggered by inferior lobe stimulation in bluegill sunfish, *Lepomis machrochirus* (Demski and Knigge, 1971), the mouthbreeder, *Tilapia macrocephala* (Demski, 1973), the common carp, *Cyprinus carpio* (Redgate, 1974) and the goldfish, *Carassius auratus* (Savage and Roberts, 1975).

The experiments in *Tilapia* indicated that fish would frequently snap up gravel during stimulation, a response that could also be released by injection of colorless food extracts into the tanks of unoperated animals (Demski, 1973). This observation led to the suggestion that the electrical stimulation

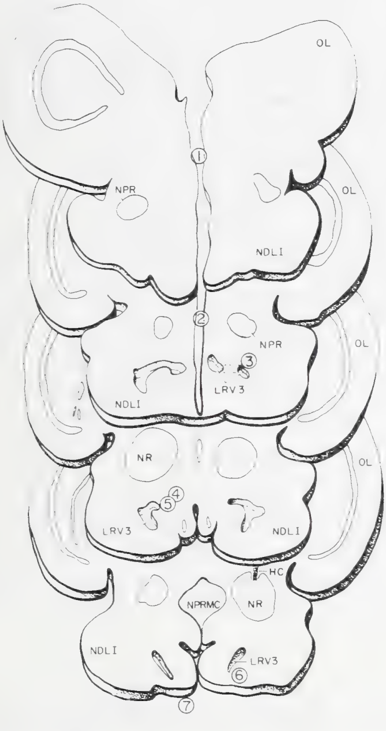

Fig. 1. Anatomical localization of sites of electrical stimulation in the brain of the cichlid fish, *Tilapia macrocephala*. Stimulation points are plotted on a series of Nissl stained transverse sections through the hypothalamic inferior lobes; the upper section is the most rostral. Feeding responses, including snapping up gravel, were evoked with low level stimulation (up to 50 μA) from sites 1-6. Sites 1 and 2 are just medial to the position of the medial forebrain bundle and Sites 3-6 are in the inferior lobes adjacent to the lateral recess of the third ventricle. Site 7 is ventral to the brain surface. The dashed line represents the track of a moveable electrode along which Site 4 was located. The solid dot at the bottom of the dashed line indicates the Prussian-blue marked ventral termination of the track. Abbreviations: HC, horizontal commissure; LRV3, lateral recess of the third ventricle; NDLI, nucleus diffuses lobi inferioris; NPRL, nucleus prerotundus (preglomerulosus) pars lateralis; NPRMC, nucleus prerotundus (preglomerulosus) pars medialis, commissural portion; NR, nucleus rotundus (glomerulosus); OL, optic lobe. (From Demski, 1973)

was triggering a normal olfactory input into the inferior lobe. Indeed, stimulation in the telencephalon near the medial forebrain bundle, the pathway known to carry olfactory tract fibers to the hypothalamus in fishes and other vertebrates (Pfaff and Gregory, 1971; Finger, 1975; Davis, 1978), also resulted in feeding responses (Fig. 1). Grimm's (1960) earlier observation that feeding could be evoked by olfactory tract stimulation in goldfish was also consistent with this idea.

Electrical stimulation experiments have also been carried out in free-swimming nurse sharks, *Ginglymostoma cirratum* (Demski, 1977). Feeding and related responses were evoked in a few cases. Most of the positive sites were located in the dorsal part of the inferior lobe just above and adjacent to the lateral recess of the third ventricle (Fig. 2). In one instance, food (cut fish soaked to remove most of its juices) was repeatedly mouthed and chewed only during the stimulation periods. The only other feeding responses were elicited at much higher thresholds from areas in the basal telencephalon (Fig. 2). The distribution of feeding sites in the nurse shark hypothalamus corresponds topographically with those found in teleosts (see further discussion below) and this comparative observation, among other considerations, led to the designation of the low threshold area of the inferior lobe as the "hypothalamic feeding area" or HFA (Demski, 1981).

Bilateral lesions in the vicinity of the HFA in goldfish result in drastic losses of feeding activity (Roberts and Savage, 1978) and growth (Peter, 1979). These results are consistent with the above mentioned stimulation studies in indicating that the inferior lobe seems to be critically involved in normal feeding. Recent electrophysiological studies also support this idea. With the use of metal microelectrodes, multiunit and single neuron recordings were made in the HFA in immobilized goldfish (Demski, 1981). Cells in the HFA were activated by electrical stimulation of both the olfactory tracts and the gustatory areas of the medulla (vagal lobes). Injection of food extracts and other chemical stimuli into the fish's mouth also activated neurons in the area. The results support Herrick's original suggestion that the inferior lobe was involved in analyzing chemical information relevant to feeding (see above).

The results of several anatomical studies with modern tracing techniques such as horseradish peroxidase have essentially confirmed Herrick's original observations concerning the connections of the teleost inferior lobe. In various species, it has been demonstrated that HFA receives second and third order gustatory fibers (Finger, 1978; 1981; Morita et al., 1980); at least an indirect input from the olfactory bulb (Finger, 1975; Venegas and Ebbesson, 1976; Davis, 1978; Demski, 1981) and sends axons to motor systems such as the efferent nuclei of the trigeminal and facial nerves (Luiten and van der Pers, 1977). With respect to the HFA of sharks, it is known that the area receives a strong input from the lateral part of the contralateral telencephalic hemisphere (Ebbesson, 1972; Northcutt, 1978). Whether or not this pathway carries olfactory information is not known. Central

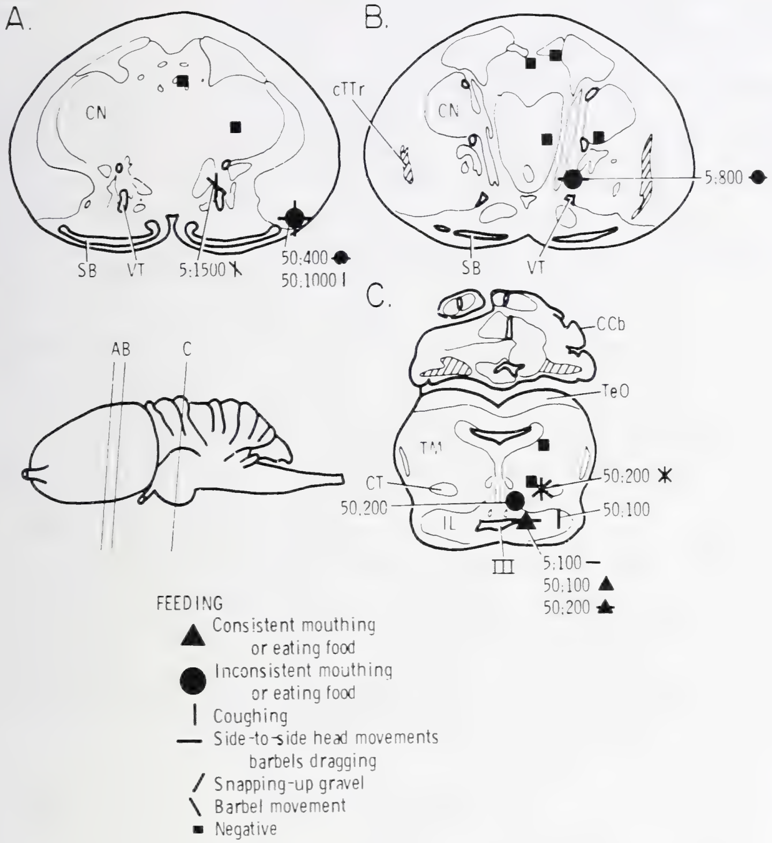

Fig. 2. Representative transverse sections of the nurse shark brain illustrating sites from which feeding responses were evoked by electrical stimulation. Abbreviations: CCb, corpus cerebelli; CN, central nucleus of the telencephalon; Ct, central nucleus of the thalamus; cTTr, crossed thalamo-telencephalic tract; IL, inferior lobe of the hypothalamus; SB, area superficialis basalis; TeO, optic tectum; TM, tegmentum of the midbrain; VT, telencephalic ventricle. (From Demski, 1977)

gustatory systems in elasmobranchs have not been mapped nor have the output pathways of the hypothalamus.

In summary, there appears to be considerable anatomical, electrophysiological and behavioral evidence that the dorsal and periventricular areas of the inferior lobe are involved in the mediation of feeding in teleosts. Far less is known concerning the function of this region in elasmobranchs. The available information, although limited, is consistent with its having a role similar to that proposed for bony fishes.

Comparative Anatomy of Hypothalamic Feeding Areas in Fishes—The basic structure of the hypothalamic inferior lobes is perhaps best exemplified by the pattern observed in cylostomes and sharks in which most of the neurons in the lobe are located in a periventricular position surrounding the lateral recess of the third ventricle (see discussion in Demski et al., 1975). This nuclear area is in turn surrounded by a cell-sparse zone of dense neurophil (see figures in Ebbesson and Ramsey, 1968; Ebbesson, 1972; Evan et al., 1976; Northcutt, 1978). A similar pattern is found in teleosts with the major exception that a large nucleus diffussus lobi inferioris is situated peripheral to the cell-sparse zone (see figures in Demski et al., 1975). It is thought that the latter nucleus becomes highly developed only in the actinopterygian line of evolution (Crosby and Showers, 1969; Demski et al., 1975). Based on these general considerations, it can be suggested that the periventricular nucleus and its surrounding cell-sparse zone are at least grossly homologus structures in the two groups of fishes. Because these structures represent precisely the area from which feeding can be evoked in both sharks and teleosts, it can also be suggested that the basic function of the region in some ancestor common to these fishes was also the control of food intake. Similar distributions of catecholamine-containing nerve fibers have also been observed in this area in both teleosts (Baumgarten and Braak, 1967; Parent et al., 1978) and sharks (Wilson and Dodd, 1973). Besides supporting the proposed homology, these data suggest that certain feeding mechanisms in fishes may be aminergic. This would be consistent with the aminergic feeding systems associated with the mammalian hypothalamus (Grossman, 1975).

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Academy Symposium

SHARK INVESTIGATIONS BY THE NATIONAL MARINE FISHERIES SERVICE, MIAMI LABORATORY[1]

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ABSTRACT: *Two thousand one hundred forty-three sharks, representing 6 families and 29 species, were examined from shark tournaments, taxidermy firms, fishing docks and longline vessels, from 28 February 1979 through 1 November 1980. Preliminary data on the recreational fisheries for sharks in the southeast United States, on the shark "by-catch" of the Japanese longline fishery for bluefin tuna, and on the biology of species found off southeast Florida are presented.*

RESEARCH on the abundance, distribution, and biology of sharks in the Gulf of Mexico and western North Atlantic by the Miami Laboratory of the National Marine Fisheries Service (NMFS) began in February 1979. We provide a data base for the management of the shark fisheries within the United States Fishery Conservation Zone (FCZ) in the southeast region, because within recent years, sharks have become increasingly important both as game and commercial fishes. Previous studies on some shark populations in both the Atlantic and Pacific have shown that only a relatively small proportion of the population may be harvested each year without affecting long-term recruitment to the stock. Some examples are the California soupfin *(Galeorhinus zyopterus)* (Ripley, 1946), Australian school (*G. australis)* (Olsen, 1954), and spiny dogfish (*Squalus acanthias)* (Holden, 1968) shark fisheries. Two thousand thirty-six sharks, comprising 29 species, were examined at local taxidermy firms and shark tournaments (Tables 1 and 2). An additional 107 were examined from fishing docks and swordfish longline vessels. Analysis of the shark species caught in the Japanese longline tuna fishery (shark by-catch) has proceeded on a regular basis. The data obtained from the NMFS Observer Program has provided information on the species composition and abundance in offshore pelagic regions (Table 3).

METHODS—Measurements and observations recorded from specimens included the date, area caught, species, sex, total length (TL), fork length, precaudal length, girth, and weight. The state of gestation of females was determined as gravid, mature with ovarian eggs, or immature. When the female was gravid, the pups were counted and sexed for each uterus, weighed and measured. Abnormalities such as deformities, wounds, and parasites were noted, and if time and conditions permitted, stomach contents were recorded.

TOURNAMENT SAMPLING—Tournament sampling began in May 1979 to

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[1] Contribution number 81-08M, Southeast Fisheries Center, Miami Laboratory.

TABLE 1. List of sharks sampled at shark tournaments, 1979 and 1980 by tournament name, date and species.

		Species									
Tournament	Date	SBR	LEM	TIG	BTP	NUR	BUL	GHH	SHH	OTH	TOTALS
Lake Worth, FL	5/5-8/79	16	6	5		5	3	16	4	2	57
Charleston, SC	5/9-11/80	8		1						2	11
Galveston, TX	6/6-8/80		3	3	7		4	2	3		22
Charleston, SC	7/13-15/79	4		2	6			2	1	1	9
Destin, FL	6/30-7/7/79	16		2	1		8		5	1	33
	6/28-7/3/80	21					2	3	5	4	35
Marathon, FL	7/7-8/79	2	19	4	18	17	3		1	4	68
	7/12-13/80	20	10	5	3	22		1		7	68
Charleston, SC	8/10-12/79		1	1	2						4
Charleston, SC	8/16/80	1									1
Charleston, SC	8/29-31/80	3		8	1					2	14
Pt. Salerno, FL	10/5-7/79	14	6	3	1	1	11	4			40
	9/5-7/80	25		15	1	1		4			46
Islamorada, FL	10/27-28/79			6				1	4	12	23
	10/4-5/80	5	30	14	29			3	2	18	101
N. Palm Beach, FL	10/27-28/79		1	2			6				9
Totals		135	76	71	69	46	37	36	25	56	551

SBR = Sandbar *(Carcharhinus plumbeus*, LEM = lemon *(Negaprion brevirostris)*, TIG = tiger *(Galeocerdo cuvieri)*, BTP = blacktip *(C. limbatus)*, NUR = nurse *(Ginglyostoma cirratum)*, BUL = bull *(C. leucas)*, GHH = great hammerhead *(Sphyrna mokarran)*, SHH = scalloped hammerhead *(S. lewini)*, OTH = *12 other species. (N 12).*

TABLE 2. The 11 most common shark species sampled at Pfleuger's Marine Taxidermy from 28 February through 15 May 1980.

Species	No. Males	No. Females	Unkn. Sex	Total No.
Scalloped hammerhead *(Sphyrna lewini)*	416	379	3	798
Silky *(Carcharhinus falciformis)*	115	115	2	232
Sandbar *(Carcharhinus plumbeus)*	97	77	1	175
Great hammerhead *(Sphyrna mokarran)*	41	21	1	63
Tiger *(Galeocerdo cuvieri)*	30	22	2	54
Smooth hammerhead *(Sphyrna zygaena)*	28	17	1	46
Blacktip *(Carcharhinus limbatus)*	14	31	-	45
Shortfin mako *(Isurus oxyrhinchus)*	6	13	16	35
Lemon *(Negaprion brevirostris)*	13	8	1	22
Bonnethead *(Sphyrna tiburo)*	7	13	-	20
Bull *(Carcharhinus leucas)*	4	2	6	12
16 other species*	38	37	8	83
TOTALS	809	735	41	1585

*Not listed by name because of the lengthy table and the very few specimens ($N < 12$) per species.

obtain data on sharks from areas around the southeast United States. Tournaments are periodically sponsored on the annual basis by Shark Fishing Clubs, Charter Boat Associations, and various Civic Organizations. Five hundred fifty-one sharks were sampled at 17 tournaments in 1979 and 1980 (Table 1). The most common species entered was the sandbar (*Carcharhinus plumbeus)*, comprising 21.4% of the total in 1979 and 27.9% in 1980. The largest individual entry for both years was the tiger shark *(Galeocerdo cuvieri)*, weighing 379.8 kg in 1979 and 411.4 kg in 1980.

Catch and effort data were obtained when possible, but the data collected are not complete and may be biased due to the different types of tournaments, absence of a set weigh-in time in some cases, and the large number of anglers not reporting in. Most tournaments focused on larger sharks because minimum length and weight rules were in effect. Fishing boats were small (<7.6 m) and the fishing areas were close to shore; therefore, bias towards inshore species exists.

TABLE 3. Species composition of the shark by-catch from the Japanese longline tuna fishery in the Atlantic and Gulf of Mexico Fishery Conservation Zones (FCZ') as reported by the NMFS 1979 Observer Program.

Month	Whitetip (*C. longimanus*)	Blue (*P. glancas*)	Tiger (*G. cuvieri*)	Hammerhead***	Thresher***	Porgeagle (*Lamna nasus*)	White (*C. carcharias*)	Mako***	Other**	Totals
				NORTH ATLANTIC						
January		312			3			28	14	357
February		12						2		14
March-June				No Fishing or Observer Coverage						
July	1	699	1	1	4		25	10	52	793
August	39	693	3	29	27		20	66	199	1,076
September	114	135	2		2	1		28	76	358
October	44	931	5	8	18	2	10	59	44	1,121
November	9	1,442	1	1	12	1	16	123	107	1,712
December	1	753		1	2			39	1	797
Year total	208	4,997	12	40	68	4	71	355	493	6,228
				GULF OF MEXICO						
January				No Fishing or Observer Coverage						
February	3	8	5		19		4	34	17	90
March	2		5	1	11		11	76	28	134
April	1	1	6		18	1	20	78	17	142
May-December				No Fishing or Observer Coverage						
Year Total	6	9	16	1	48	1	35	188	62	366

*Preliminary data from the NMFS observer program for Japanese longline fishery for tunas in Atlantic Gulf of Mexico FCZ's.

**Includes the following species: Silky, Blacktip, Dusky, Sandbar, Dogfish, Bignose, Lemon and unknowns.

***Hammerhead include *Sphyrna mokarran*, *S. lewini*, and unknown hammerhead sharks.
Thresher includes *Alopias vulpinnus* and *A. superciliosus*.
Mako includes *Isurus oryrhincus* and *I. paucas*.

Taxidermy sampling—Sampling at a local taxidermy firm was conducted on a daily basis from 28 February 1979 through 15 May 1980. One thousand five hundred eighty-five sharks of 3 families, comprising 27 species were examined (Table 2). The scalloped hammerhead (*Sphryna lewini)* was the most common shark mounted with 798 specimens. This was followed by the silky shark (*Carcharhinus falciformis)* and the sandbar shark (*C. plumbeus)*, with 232 and 175 specimens, respectively. The majority of sharks was brought in for mounting between December and May, mainly because the fishing and tourist seasons off southeast Florida coincide at this time.

Japanese longline fishery shark by-catch—Since the implementation of the NMFS Observer Program for the Japanese longline fishery for tunas in the Gulf of Mexico and Atlantic FCZ's in 1978, an impression of the composition and abundance of offshore, pelagic sharks has been formed. As reported by the observers (Table 3), the most common species taken in the Atlantic FCZ in 1979 was the blue shark (*Prionace glaucas)* comprising 80% of all identifications. In the Gulf of Mexico FCZ, the 2 species of mako shark, *Isurus oxyrhineus* and *I. paucas*, comprised 50% of all identifications. Catch rates (per 100 hooks) for the shark "by-catch" were significantly higher overall for the Atlantic than the Gulf of Mexico, approximately 0.9 and 0.1, respectively.

Results and Discussion—Sufficient numbers of specimens of the following species were examined to permit comment: *Sphyrna lewini* (scalloped hammerhead), *Carcharhinus plumbeus* (sandbar), *C. falciformis* (silky), *Galeocerdo cuvieri* (tiger), *S. mokarran* (great hammerhead), *C. limbatus* (blacktip) and *Negaprion brevirostris* (lemon).

Scalloped hammerhead—*S. lewini* was the most common species examined; the majority was caught off southeast Florida between January and June. A possible migration through the area and high fishing effort contributed to the number. Males appear to arrive first, followed by females about a month later. Mature males possessed rigid calcified claspers and mature females, generally, were in a pre- or postpartum condition.

Data on unborn pups were taken when conditions permitted. An average of 18 pups (maximum number seen was 31) was found and a 1:1 sex ratio occurred. The largest pup measured 49.0 cm (TL) in length and weighed 0.6 kg.

The smallest specimen measured 75.0 cm (TL) and weighed 2.0 kg. The largest female was 312.0 cm (TL) in length and weighed 171.8 kg. The largest male measured 296.0 cm (TL) and weighed 140.9 kg. Eight hundred twelve total lengths (TL) were used to obtain size frequency ranges of the most common size brought in for mounting or entered in shark tournaments. Sixty percent of the total fell between 221.0 and 280.9 cm (TL).

Sandbar—Three hundred and ten sandbar sharks (*C. plumbeus)* were examined, 80% falling in the 181.0-221.9 cm total length range. The largest measured 245.0 cm (TL) and weighed 78.2 kg and the smallest measured

124.0 cm (TL) and weighed 11.9 kg. An average of 7.2 pups (the largest 62.0 cm in length) was found from 26 gravid females.

SILKY—Subadult specimens of *C. falciformis* were examined year-round in the southeast Florida area with 86% in the 81.0-140.9 cm (TL) range. The only gravid female observed had a litter of 10 pups (1:1 sex ratio) which averaged 32.2 cm (TL) in length. She was the largest seen (271.0 cm (TL) and weighed 66.7 kg). The smallest free-swimming silky shark was 47.5 cm (TL) in length.

TIGER—The tiger shark (G. CUVIERI) was found in all areas, sizes ranging from the smallest at 106.7 cm (TL) and 5.5 kg., to the largest at 346.0 cm (TL) and 411.4 kg. Litter sizes ranged from 21-67, with an average of 37. The largest pup was 77.0 cm (TL) long and weighed 1.3 kg. A porpoise head, unidentified turtle parts, a goat's leg, conch operculae, bird feathers, cans, plastic bags, and a 6′ X 2′ section of seine net were among the items found in the stomachs.

GREAT HAMMERHEAD—Large *S. mokarran* were the dominant sizes seen, with 32% in the 281.0-300.9 cm range. The largest examined was a 385.0 cm (TL) female which weighed 302.3 kg. The smallest measured 162.6 cm (TL) and weighed 22.7 kg. The average litter was 16.4 pups; the largest pup measured 65.0 cm (TL) and weighed 1.2 kg.

BLACKTIP—The most common size of blacktip sharks (*C. limbatus)* was in the 141.0-180.9 cm (TL) range. The largest was 187.5 cm (TL) and 33.2 kg. Ten small sharks (average weight of 1.9 kg) were caught during the Islamorado tournament and were the smallest free swimming specimens examined. Twenty-two females were gravid; the average size litter was 5.0 pups. The largest pup measured 57.0 cm (TL) and weighed 1.0 kg.

LEMON—A lemon shark *(N. brevirostris)* 282.7 cm (TL) long which weighed 151.4 kg was examined in Galveston, Texas, and was the largest specimen examined. Free swimming specimens as small as 65.0 cm (TL) in length and 2.0 kg in weight were seen at the Islamorada tournament. Gravid females examined had an average of 16 pups, with the maximum at 24.

ACKNOWLEDGMENTS—We thank Pflueger's Marine Taxidermy, Inc., Hallandale, Florida and Gulf Studios, Inc., Destin, Florida for allowing us to examine sharks brought in to their firms. To the many people and organizations involved with shark tournaments goes our sincere appreciation.

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ROLE OF THE LEMON SHARK, *NEGAPRION BREVIROSTRIS* (POEY) AS A PREDATOR IN THE TROPICAL MARINE ENVIRONMENT: A MULTIDISCIPLINARY STUDY

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ABSTRACT: *Sharks are numerically important members of many marine communities, yet little is known of their role in these ecosystems. Recent technical developments in laboratory and field have facilitated investigation of the autecology of the lemon shark* Negaprion brevirostris *(Poey). This littoral shark is abundant, lives well in captivity and is ideally suited for investigation. Over the past 24 mo we have marked and released 984 young sharks during a study of population dynamics. Each was injected with tetracycline for age validation. We tracked individual sharks for hundreds of km via ultrasonic telemetry thus determining activity rates, movements, home ranges and diel periods. We evaluated blood gas parameters, food intake, digestion, growth, resting and routine metabolism in the laboratory. These data provide estimates of the energy budget of the lemon shark and form a basis for understanding the flow of energy from environment to shark. Our tentative conclusion is that an adult lemon shark must remove nearly 1500 g of fish daily (1.6 x 10^6 calories) to account for its vital activities.*

THE importance of predators in the functioning of ecosystems, especially with reference to population dynamics and exchanges of energy between trophic levels, was long ago shown by the work of Volterra (1928). Predator effects are no less important in the marine than the terrestrial realm. Smith (1974), Steele (1974), Hassell (1976) and others have demonstrated via computer models that predators can exert both stabilizing and oscillating influences on ecosystem dynamics. Such computer simulations of population interactions typically include factors taken from detailed studies on the life history of teleost predators (Glass, 1971). Yet, in the tropical marine environment, the influence of one of the most abundant and important groups of predators—the sharks—has been almost entirely overlooked (Strasburg, 1958; Moss, 1972; Soucie, 1976; Gruber, 1977; Gruber and Myrberg, 1977). At present, very few reasonably detailed autecological studies on sharks have been published (i.e., O'Gower and Nash, 1978; Clarke, 1971; Wass, 1973).

Attempts to gather ecological data have been frustrated because many sharks are swift, shy and live in a concealing medium (Nelson, 1977); and because they are difficult to keep in captivity (Martini, 1978; Gruber, 1980; Gruber and Keyes, in press). In addition, they have not been systematically exploited (Holden, 1977). As a consequence, little is known of their behavior (Gruber and Myrberg, 1977), population dynamics (Holden, 1974), or bioenergetics (Brett and Blackburn, 1978). Yet, any general balance sheet for flow of energy in the tropical marine environment must take the elasmobranchs into account because important sinks (such as sharks) and sources of energy must be quantified if interconversion between them is to be specified (Kowal, 1971; Rykiel and Kuenzel, 1971; Williams, 1971; Smith, 1974; Hassell, 1976).

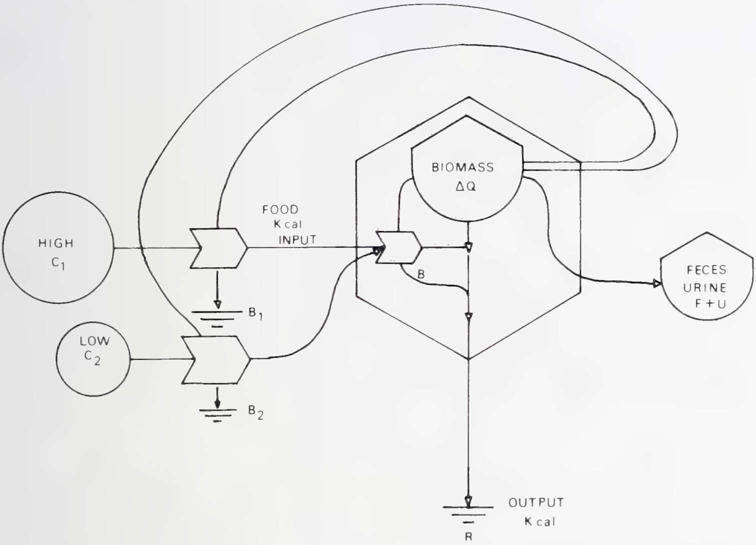

FIG 1. Conceptual model of the input/output relations describing flow of energy from environment through the lemon shark. The basis for the model derives from Ricker's (1948) concept of fish production: The energy circuit language was developed by Odham (e.g., 1971). C = environmental energy source (food); B = calorie losses from certain behaviors; ΔQ = production; R = respiration.

At the beginning of this program I predicted that real progress toward the realization of the above objectives could be made if a study of the autecology of the lemon shark (*Negaprion brevirostris*) were undertaken. This is because its size, abundance, generalized structure, ease of capture and adaptability to captivity lends itself to systematic investigation. Thus far, these factors have interacted to confirm my prediction; namely, that with the lemon shark as a model species many of the heretofore intractable elements of autecology of a tropical marine shark are soluble.

I have taken a bioenergetic approach to the ecological investigation of the lemon shark and seek to specify the energy budget of this species by laboratory determination of scope of activity, power-performance curves, rates of food intake and digestion, specific dynamic action, periods of peak activity, and growth rates. Field data including population parameters will then be integrated with the laboratory results into a conceptual model of energy flow through the species (Fig. 1). This model should account for the basic facts of metabolism, energy exchange within the environment and biological production in the lemon shark. Thus I will be able to specify the rate and amount of energy this predator must remove from the environment to maintain itself at observed behavioral levels and growth rates. This information can be of practical use by the Everglades National Park survey of marine communities because the lemon shark is one of the most numerous predators within Park boundaries. Indeed, much of our field work utilizes a shark population within the Park. Fishery management provides a second practical outlet for these data. The proposed model in providing a baseline for production in sharks will be of significance to fishery scientists because they have been mandated by public law to develop a management plan for the rational exploitation of shark stocks. The overall significance of this work relates to the flow of energy through natural systems up to and beyond the community level; a major consideration in population ecology (Steele, 1974). Finally, and perhaps most important, this study will advance our meager knowledge of ecological and evolutionary adaptations of sharks.

I review progress of this project and present results after 24 mo of effort. While this paper represents an overview, further results of the ongoing studies described herein will be published in the future.

Field Studies

Part I: Mark, Recapture Program. Measuring biological production in the lemon shark is central to the objectives of this program. The only reasonable way to understand production in a free-ranging animal such as the lemon shark is through mark-recapture techniques (Holden, 1977). I have reviewed the results of 27 tagging studies on elasmobranch fishes, some of which are referred to below, and conclude that it should be possible to estimate population parameters, age and growth and the long-term movements of the lemon shark by mark-recapture techniques. Results from fewer than 30 tagging programs utilizing elasmobranch fishes have been published and most, but not all, have used commercially exploited species (Casey et al., 1978; Olsen, 1954; Stevens, 1975). Various marking schemes have been tried including aluminum straps around the caudal peduncle (Clemens, 1932), snout and cheek tags (Templeman, 1954; Jensen, 1969; Hansen, 1963), plastic disc tags (Thorsen, 1973), dart tags (Casey et al., 1978; Clarke, 1971), internal tags (Olsen, 1954), and branding (Anon., 1963). Some controversy exists about which tag is best but most workers agree that multiple tags bring the highest returns, while internal tags last longest. Thus all the lemon sharks in this study were marked with multiple tags as described below.

I surveyed the various analytical techniques available for population censusing including deterministic models such as those of Schnabel (1938), Ricker (1948) and Bailey (1951) as well as the stochastic models of Jolly (1966) and Seber (1965). Prior to the study I expected problems in marking large numbers of sharks in a relatively short time and thus chose the stochastic model for estimating population parameters. It turned out that I was able to tag nearly 1000 sharks in about 4 mo. However, I did not meet the criterion of strict random sampling (as is true of most marine studies) and so statistical analysis of the recapture data, especially the population census, must be confirmed by an independent technique.

Patterns of movement, another objective of the tagging program, can be visualized by direct plotting of the recapture data on charts (Fig. 2); and quantitatively analyzed by evaluating the coefficient of dispersion as set forth in Jones (1966, 1976, 1977).

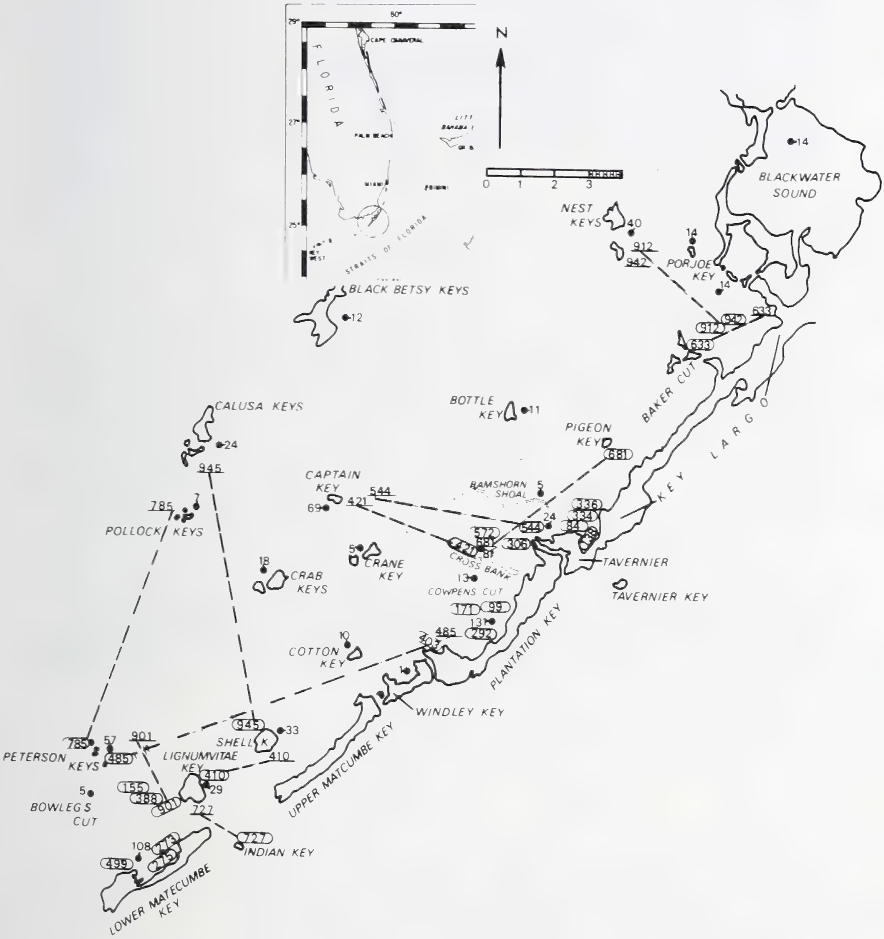

FIG. 2. Capture-recapture locales for 852 lemon sharks marked and released in summer 1980. Filled circles show the exact spot and number of sharks captured. Individual recaptures (as of October, 1980) are open ovals. The numeral within each oval refers to the tag number. Migration is shown by a dotted line. The scale is in nautical miles and the inset maximum at the upper left shows the general location of the study area in Florida Bay.

Few studies on age and growth of sharks have been attempted. This is because most elasmobranch populations have not been systematically exploited. Also, the structure of their hard parts does not lend itself to aging techniques developed for teleosts. More recently, counts of vertebral rings have formed the basis for estimating the age structure of several shark populations (Olsen, 1954; Aasen, 1963; Daiber, 1960; Parker and Stott, 1965; Holden, 1972; Stevens, 1975). All these studies except Holden and Vince (1973) lack the crucial element of fixing the interval between ring formation. In this regard, all sharks released in this study have been injected with tetracycline. Thus I plan to both age our sharks and validate the results by methods outlined in Holden and Vince (1973). It should be noted that Holden and Vince studied a temperate skate while our subject is a tropical shark.

Most studies of growth in sharks have followed the model given by von Bertalanffy (1938, 1960). Thus, Holden and Meadows (1962), Aasen (1963, 1964), Wass (1973), Holden (1974), Ketchen (1957), Stevens (1975), and Tanaka and Mizue (1979) provided von Bertalanffy parameters, describing growth in several elasmobranch species. In the present program, growth data from captive lemon sharks are combined with data on growth in the field as indicated by tag returns. Such an approach has been recommended by Paloheimo and Dickie (1965, 1966) and Holden (1974, 1977). Thus I will be able to directly and empirically determine growth in this species to evaluate the appropriateness of von Bertalanffy parameters in describing growth in elasmobranchs (see below).

The last section of the field study encompasses food and feeding of the lemon shark. Studies on prey items of sharks, especially carcharhinids, suggest that they are opportunistic carnivores with some selectivity (Bonham, 1954; Backus et al., 1956; Jensen, 1965; Wass, 1971; Jardas, 1972; Stevens, 1975). A few species appear to be indiscriminant scavengers (Strasburg, 1958; Springer, 1960). The lemon shark feeds on both crustacea and fish but few details are known (Baughman and Springer, 1950; Clark and von Schmidt, 1965; Dahlberg and Heard, 1969; Springer, 1950). I have confirmed the presence of teleost, elasmobranch and crustacean remains in the stomach of the lemon shark and plan to address this question in detail during the coming year.

In summary, an essentially untouched population of lemon sharks has been sampled and systematically marked. Returns should provide the data for an understanding of age, growth, survival, mortality, food and feeding and population numbers. Such data will be integrated into a model (Fig. 1) of the input/output energy relationships of this species.

RESULTS OF THE MARK-RELEASE PROGRAM — I have developed a tagging protocol for the systematic marking of relatively large numbers of lemon sharks utilizing multiple marks. The protocol, consists of weighing, measuring, sexing, freeze branding, injecting (25 $mg.kg^{-1}$ tetracycline; Holden and Vince, 1973) marking (dorsal fin and dart-tag) and implanting a plastic internal tag

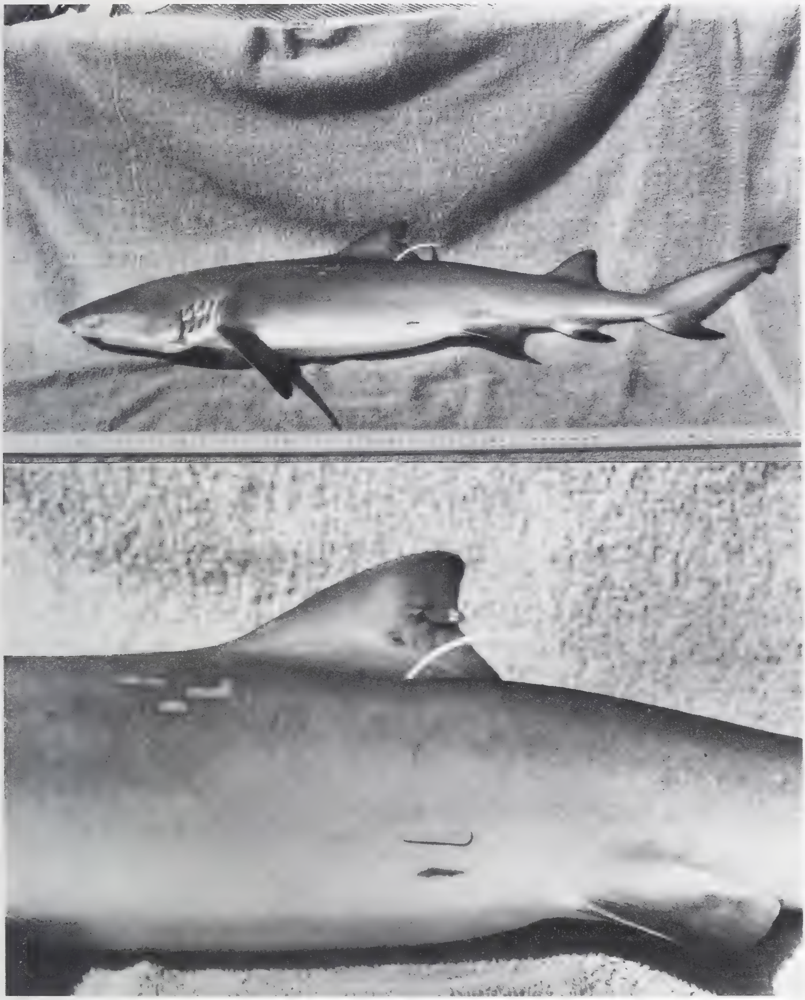

FIG. 3. Photograph of a 70 cm total length (TL) lemon shark showing 3 external marks used in the tagging protocol: the coded freeze brand; the dorsal fin tag (#2) and the "spaghetti" tag. The black mark in front of the pelvics is the healed scar received during surgical implantation of a thin plastic internal tag. In addition each shark received an internal tag and an intramuscular injection of tetracycline (25 mg.kg^{-1}) for age validation.

(Fig. 3). Sharks were collected in Florida Bay by hook and line or cast net and brought to 1 of 4 previously established collection centers. They were allowed at least 24 h recovery and then marked. Many, but not all, were released at the original capture site. In this manner 64 sharks were released in 1979 and 904 in 1980. The tagged sharks, mostly "year I" juveniles, ranged in precaudal length and weight from 33.5 cm to 152 cm and 0.5 to 12.0 kg, respectively. Figures 4 and 5 show the size frequency, and length/weight relationship for over 800 male and female sharks.

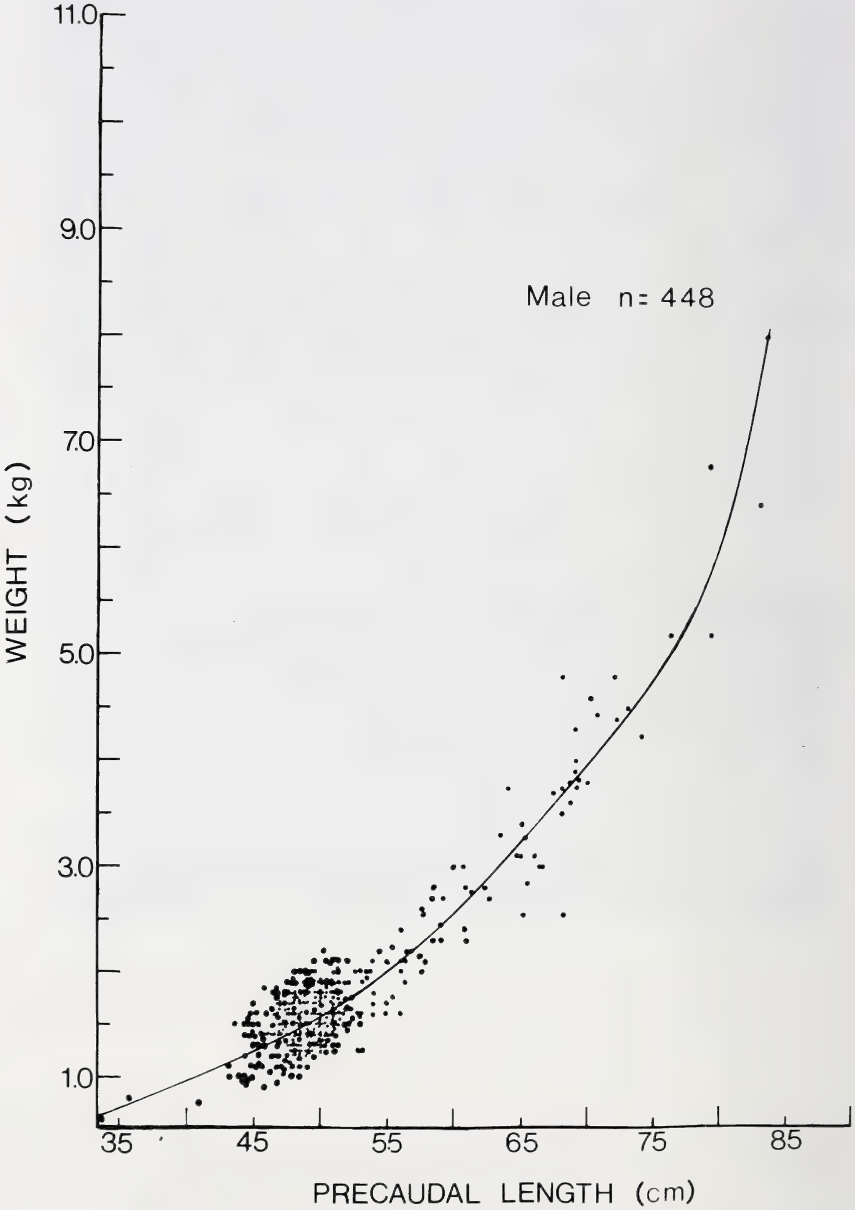

FIG. 4a. Precaudal length vs. wet weight of 448 male lemon sharks marked and released in the summer of 1980. The cluster of points at 50 cm and 1.5 kg represents the average newborn size of this species. The curves are drawn by eye and no obvious differences can be seen between the sets of data corresponding to the males and females.

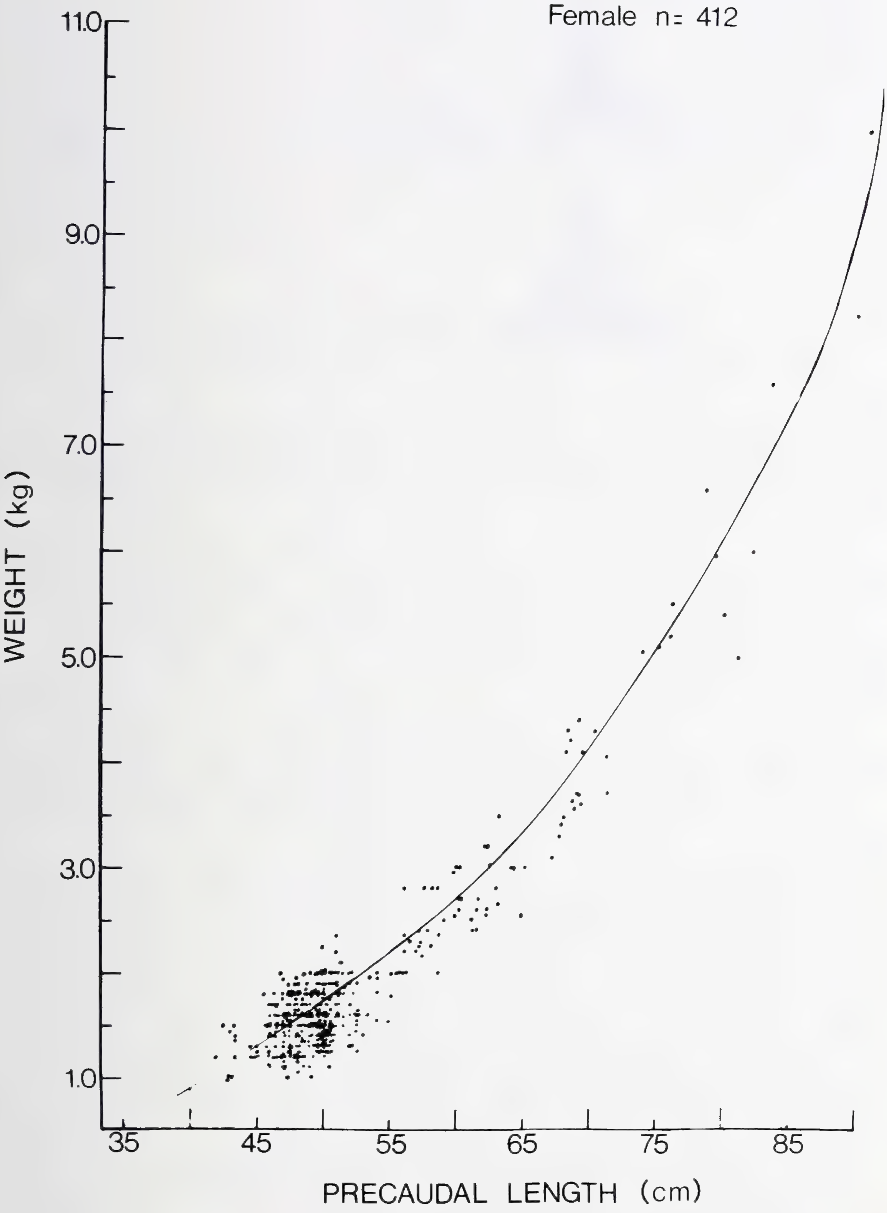

FIG. 4b. Precaudal length vs. wet weight of 412 female lemon sharks (see Fig. 4a for further explanation).

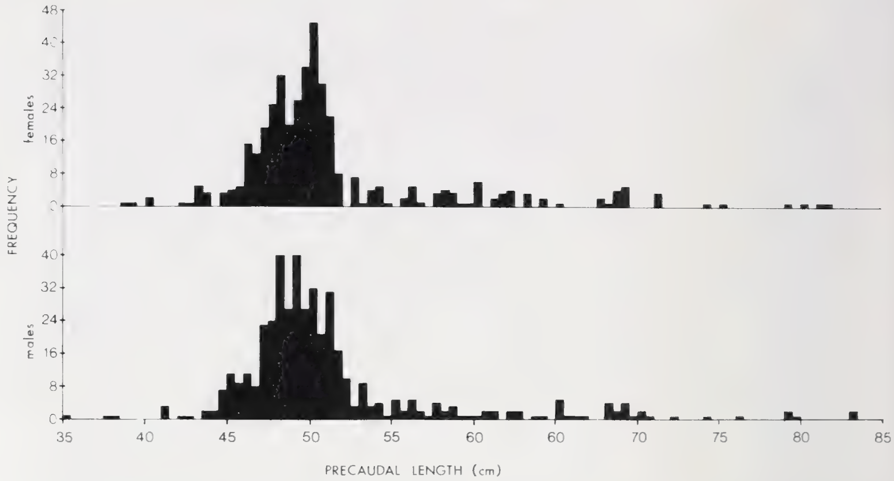

FIG. 5. Length-frequency histogram for 860 male (lower curve) and female (upper curve) lemon sharks marked and released in the summer of 1980. Petersen data reflecting year classes are not obvious in these distributions because the cath method strongly selects for newborn and very young sharks.

The tagging program was publicized in hopes that recaptures would be released so that the sharks could stay in the field for a reasonable period of growth. In addition, the dart tag had the words "release shark-reward" imprinted on the plastic tube. Yet 4% of our tagged lemon sharks were recaptured. Anglers noted that all recaptures were in good condition except two. These apparently had ocular lesions and were thin and generally "unhealthy." The recapture of sharks #912 and 942 after only 2 da at liberty suggests that the tagging protocol does not significantly deter lemon sharks from feeding.

During the 18 mo period from June 1979 to December 1980, 41 tagged lemon sharks were recaptured by anglers. Of these, 20 died (mostly consumed by humans) and 21 were released. The average time at large was 45 da, during which 15 sharks were recaptured less than 2 km from their original release site. One shark (#41) was recaptured twice. Twelve of 40 sharks moved an average of 4.8 nautical miles but some of this migration was due no doubt to displacement and release from the original capture site. Thus results from this study confirm Starck's (unpublished) findings of 12 yr ago, that young lemon sharks apparently do not migrate in the first year of life. The 4% return rate also indicates that I should eventually be able to recapture 10% of the tagged sample because most of the 1980 recaptures were caught incidental to sportfishing.

A control study on the effects of multiple tagging was carried out on a colony of captured lemon sharks (16 males, 18 females; 47-63 cm precaudal length) held under seminatural conditions in an open, flow-through system. Sharks were randomly assigned to 1 of 7 groups and manipulations, including all tagging combinations, and several dose levels of tetracycline were administered. The results suggested that unmarked lemon sharks grew at a rate somewhat faster than their marked conspecifics during the 89-da test period. For example, the weight gain was 8% higher in the 10 unmarked subjects compared to the marked sharks. The overall average increase in length was about 11%. Thus the average shark increased from 55 to 60.5 cm (precaudal length). This represents an average growth of 0.62 $mm.d^{-1}$. Males grew somewhat faster than females. If a replication of this study confirms the growth differences I will have to account for the tagging factor in the final analysis of growth.

Part II: ACOUSTIC TELEMETRY OF THE LEMON SHARK. Little is known about the activities of sharks under natural conditions (Nelson, 1974, 1977; Myrberg, 1976; Myrberg and Gruber, 1974; Gruber and Myrberg, 1977). Our ignorance of shark behavior stems, in large part, from difficulties in observing under field conditions. Beside the inherent danger, unobtrusive observation of sharks is usually not possible because they are wide-ranging animals, shy of divers, and live in a concealing medium. Yet, if the results of this study are to have wide application, it will be necessary to extrapolate laboratory findings to the field. This is especially true if the relative importance of activity in the energy budget of sharks in their natural environment is to be assessed. Because direct field observation, except in special cases, is seriously limited, the most promising method for acquiring field data on behavior would seem to be remote telemetry perhaps combined with aerial observation.

The underwater telemetry of sharks has been only infrequently attempted. Bass and Rascovich (1965) were the first to place an acoustic transmitter on a shark. They followed several species for up to 4 hr. Yet, prior to this, Baldwin and Ingle (1964) and Baldwin (1965) developed a system to remotely trigger a syringe in a free-swimming nurse shark, *Ginglymostoma cirratum*. Because results were apparently never published, I assume the overall experiment was not completed. However, the remote system was effective at distances of up to 300 m in the ocean. Since then, Thorson (1971), Carey and Lawson (1973) and Kotchabhakadi et al. (1973) and others have used remote telemetry of sharks in various studies. Nelson and his colleagues (Ferrel et al., 1974; Nelson, 1974, 1977; Sciarrotta and Nelson, 1977; Standora and Nelson, 1977) have been preeminent in the development and employment of acoustical telemetry in the study of shark behavior. Using techniques and instrumentation developed by Nelson, I have studied field behavior in the lemon shark by acoustical telemetry. These techniques are essential to the program because they provide a link between controlled conditions of the laboratory and natural conditions of the field.

The objective of this field telemetry then is to provide data for a comparison of results from laboratory investigations with the natural unrestricted behavior of the lemon shark. It will be possible to evaluate the energetic cost of unrestricted movements of the lemon shark by comparing metabolic rate from laboratory experiments with the total activity of individuals measured in the field. A second objective will be an analysis of the feeding event in terms of frequency of feeding, time of feeding, interval between meals and specific activities correlated with prey catching. Such a study will require future development of hardware for detecting the movement of food into the shark's stomach as well as a device for remotely immobilizing the shark (i.e., Baldwin, 1965). By tracking sharks with standard short-term (5-8 da) transmitters, several other objectives related to activity can be achieved. For example, basic diel activity patterns can be established, while rates of change in locomotion, direction, depth, and velocity will demonstrate periods of peak activity. Home range and site attachment, core areas and major pathways are revealed by plotting tracks over several days (Hamilton and Watt, 1970). These can be correlated with tidal currents and other physical characteristics to establish the habitat of this species. Finally, the acoustic beacon can permit underwater interception of a tagged lemon shark so that observational data on social interactions and specific motor patterns could be collected. The overall objective will be to provide a realistic assessment of the unrestricted activities of the lemon shark so that we can evaluate its actual energetic requirements based on results from controlled laboratory studies.

Results — Major accomplishments include locating lemon shark populations, developing methods of collection and transmitter attachment (Fig. 6),

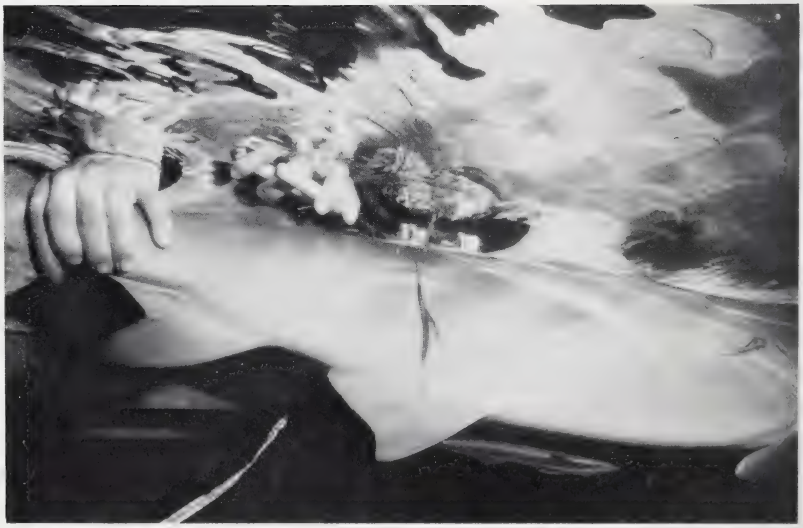

Fig. 6. Underwater photograph of a 40 kHz ultrasonic transmitter being attached between the dorsal fins of lemon shark #5 (Table 1). The hand is around the shark's caudal peduncle. This procedure requires less than 5 min and sharks do not display any obvious signs of discomfort during the surgical implantation. Note the 2 remora (*Echeneis naucrates)* maintaining position on the shark.

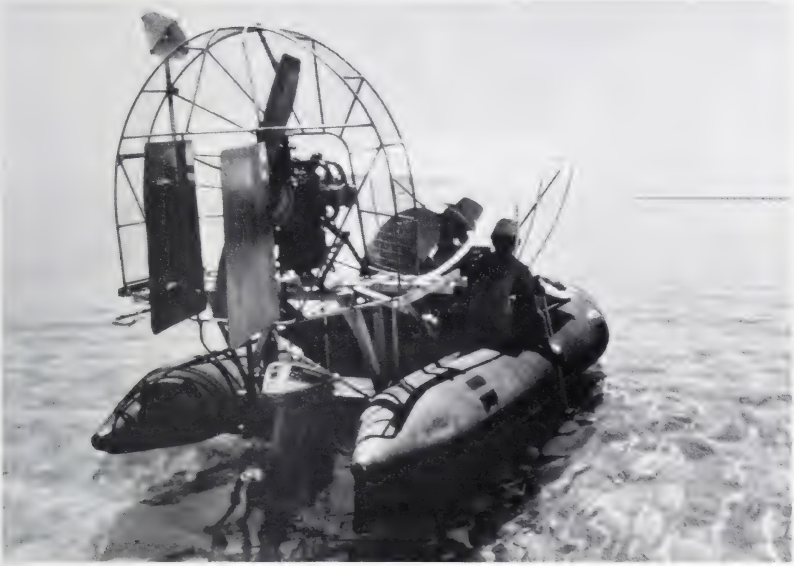

Fig. 7. Photograph of a 5.5 m Dunlop "C-craft" especially designed and modified for tracking sharks over very shallow flats. The all-rubber inflatable is fitted with a Continental 90 hp aircraft engine and an Evinrude 9.9 hp outboard motor. The fuel efficient outboard used most of the time, is adequate for tracking in water deeper than 25 cm. The aircraft engine operates to a depth of less than 7.5 cm. Crew member is shown with CAI hydrophone overboard, listening for shark.

developing and constructing a boat adapted to tracking in the shallow-water habitat of the lemon shark (Fig. 7) and finally the tracking of 7 lemon sharks for periods up to 8 da (Fig. 8). This work was accomplished during 10 cruises which comprised a total of 89 da in the field. Forty-one sharks were tagged incidental to the survey; lemon sharks were captured in the Bahamas at Bimini, Berry Islands, Gorda Cay, Burroughs Cay and West End, Grand Bahama Island. The Bimini site was eventually chosen because lemon sharks are plentiful, landmarks are abundant (upon which bearings can be taken) and because it is less than 100 km east of Miami.

We (Gruber and Nelson, in press) developed 2 methods for placing transmitters on sharks. First, a transmitter was implanted in a baitfish and this was offered to a lemon shark previously attracted by chumming. This method worked once but was deemed unreliable because we could not be certain which lemon shark took the bait. Its advantage is that it is an atraumatic method. This single shark retained the transmitter for at least 72 hrs. In the second method, a variant of the first, a 40 mm dia PVC pipe was inserted into a second shark's stomach via the mouth. The transmitter was dropped through the tube into the stomach. For the majority of trackings we settled on a surgical procedure (Fig. 6) for attaching the transmitter to the back of the shark.

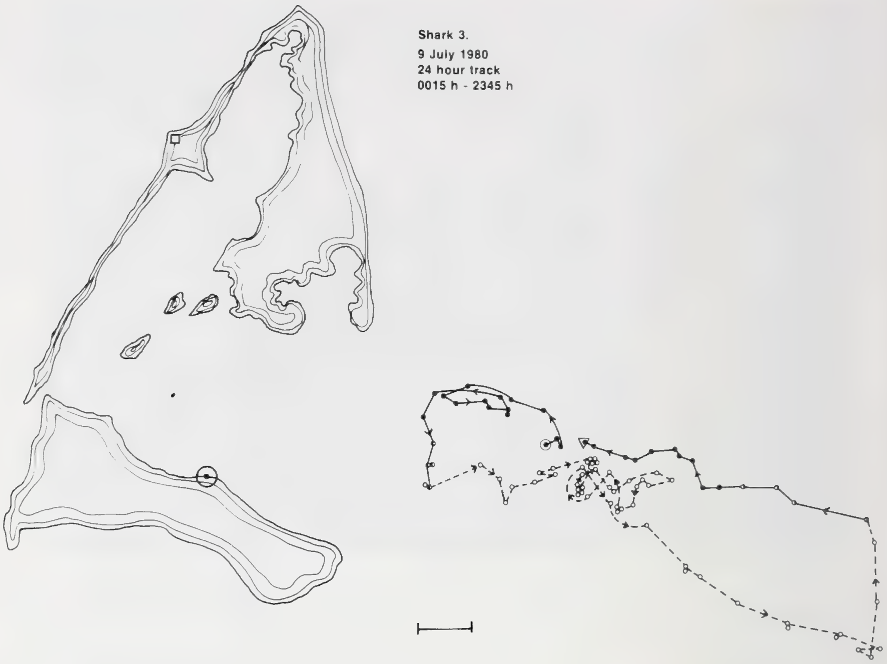

Fig. 8. Complete 24-hr track of lemon shark #3 (Table 1). Filled circles represent night-time positions and are connected with a solid line. Open circles connected by an interrupted line are position-plots during daylight hours. Half filled circles are dawn and dusk locations. Bearings were taken every 15 min. This track was made 6 da after the shark was fitted with a transmitter and released; and clearly shows the effect of the rising and setting sun in controlling the direction of movement of the lemon shark. The islands are N. and S. Bimini. North is up and the calibration mark is 1 km.

Most significant were the results (Table 1) of a single tracking lasting 150 h (location reported at 15 min intervals). Preliminary analyses indicate that, over the short-term (days), a recurring pattern of activity can be expected. In 2 cases (shark #1 and 5), strong site attachment was recorded. Current measurements at the time of tracking verified that lemon sharks do not passively drift with tidal currents as has been reported for dusky sharks (Huish and Benedict, 1977; Medved and Marshall, in press). Rather, they actively orient within their home range since, on 1 track, the shark swam more than 15 km from Bimini, thus precluding direct visual, acoustical and possibly olfactory orienting stimuli. Yet that shark returned to its original locale at Bimini the next day (Fig. 8).

Preliminary analysis of rates of movement did not reveal any period of peak activity. The lemon shark appears to be slightly more active at night. We recorded relatively intense activity during the twilight hours and the average rate of movement (1.77 km hr^{-1}) confirms this. On this basis, lemon sharks may be considered crepuscular animals, a finding which agrees with Hobson's (1968) observation on reef sharks *Carcharhinus sp.* We also found

TABLE 1. Summary of sharks tracked during ultrasonic telemetry.

Date	Number	Total Length cm	Sex	Number of Days with Contact	Contact Hours	Distance Tracked km	Remarks
13 July 1979	1	150	F	3	17:45	23.59	First tracking. Self ingested xmtr; lost each night due to shallow water, Bimini
21 July 1979	2	260	M	2	12:05	21.8	Shark went into deep water. Largest shark tracked, Burroughs Cay
3 July 1980	3	230	F	8	112:15	202.17	Longest track; attach xmtr with dart tag between dorsal fin, Bimini
7 July 1980	4	180	F	2	6:15	-	Shark heard at same time during concerted track of #3
18 Aug 1980	5	168	F	5	19:15	39.38	Shark captured in Bimini harbor; daytime refuging area, same locale for 3 da
18 Aug 1980	6	171	M	1	1:15	-	Briefly swam together with #5 and both visually sighted.
14 Oct 1980	7	178	M	4	6:30	12.61	Last tracking; velocity sensor, captured middle of Bimini flats.

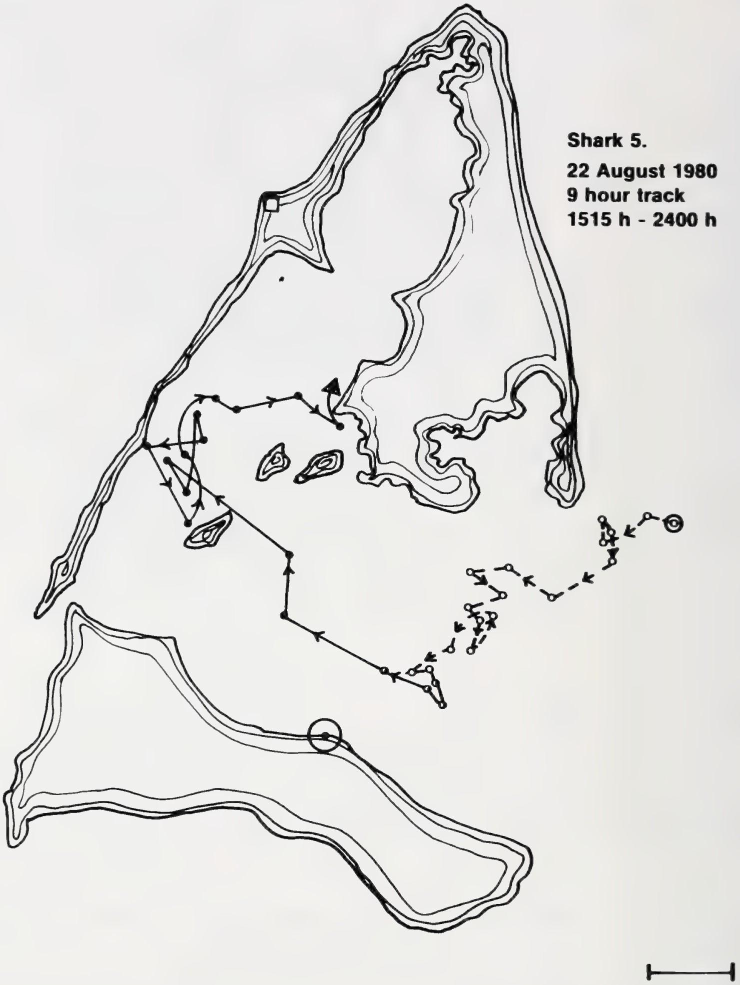

FIG. 9. Track of lemon shark #5 (Table 1). Symbols and calibration mark same as in Fig. 8. This 14-hr track made 5 da after the shark was captured demonstrates that this animal can swim over the flats and into the harbor at North Bimini.

recurring movement patterns such that different areas were visited during day and night and certain areas were repeatedly revisited during daylight hours. For example, lemon sharks can be caught in the narrow but deep harbor at North Bimini at night but we never tracked or caught any in the Harbor during daylight. We first thought that they entered the harbor from the ocean through a cut between North and South Bimini as suggested by Hodgson (1971). Subsequent trackings demonstrated that 1 shark entered the harbor at night by swimming westward over the shallow flats (Fig. 9). In the daytime it remained in shallow water (> 1 m) where it was visually and acoustically observed several times, along with a second transmitting shark caught the same night in the harbor. This locale may represent a refuge area (Hamilton and Watt, 1970). Additional aerial observations confirmed that concentrations of lemon sharks can be found in this area during daytime.

Because the directional telemetry receiver allows us to home in on the shark, we observed lemon sharks on several occasions in their natural environment. Two observations of note were made: First, on several occasions social interaction between sharks was seen. The motor pattern termed FOLLOW (Myrberg and Gruber, 1974) in which a following shark(s) copies the movements of the preceding shark for at least 4 body lengths, was recorded 9 times. Another factor suggesting sociality is the number of times signals from 2 sharks were heard simultaneously. In an area of ca. 100 km^2 with only 2 sharks transmitting, one would not expect to hear both animals simultaneously unless there were core areas or pathways or unless there was social interaction or both. The other visual observation concerned the relation between jackfish (Carangidae) and lemon sharks. On 5 occasions during 3 different tracks, schools of blue runner *Caranx fuscus* and other jack species were observed in association with the sharks. This was an interactive association because the shark appeared to orient toward the jacks and vice versa. Carangids are known to associate with sharks, but the benefit of such association is said to favor jacks on account of reduction of predation (Eibl-Eibesfeldt, 1970). However, our observations suggest that jacks may lead sharks to possible prey items. While tracking sharks underwater on 3 occasions, we became surrounded by schools of rapidly moving jacks. The shark (#3) that we were tracking closely investigated us on each of these occasions. As the telemetered shark swam off, so did the jacks, obviously orienting to this shark. These observations suggest a tentative hypothesis: at certain times, lemon sharks utilize the expanded sensory-motor apparatus of schools of jacks as an aid in prey finding and thus benefit from the association. This implies a kind of mutualism. However, other hypotheses are available to explain these observations.

One final point is that lemon sharks are not restricted to shallow flats. We tracked a 2.8 m lemon shark (#2) for 2 da at Burroughs Cay, Bahamas. At dawn on the first day 2 h after the transmitter was implanted, this shark swam over the dropoff several km into the pelagic environment at considerable depths (400 + m). The next morning it was located on a reef in 28 m of water.

Laboratory Investigation

Part I: Metabolic Rate. In accordance with my primary objective of balancing the energy budget for the lemon shark, bioenergetics has assumed a central importance in this study. The basis for this arises from the first law of thermodynamics which implies that energy available for biological work, derived through metabolic reactions, is equal to heat produced (Kleiber, 1975). When Rubner (in Brody, 1945) introduced the method of indirect calorimetry, he showed that oxygen consumption provides a reliable estimate (within 1%) of heat production. Thus oxygen uptake closely estimates metabolism, which may be defined here as the sum of reactions providing useful energy for the organism (Fry, 1971). The method of respirometry has often been used to measure metabolism of teleosts (Brett, 1962; Pierce and Wissing, 1974; Solomon and Bradfield, 1972; Winberg, 1956, etc.). Very few comparable studies for the elasmobranchs have been published.

For investigation of the energetics of aquatic vertebrates, 3 levels of metabolism have been recognized: standard, routine and active metabolism. These distinctions represent a gradual increase of metabolism from the lowest or basal levels to the highest sustained rate of activity (Brett, 1962; Fry, 1971; Winberg, 1956). All 3 levels must be evaluated however if laboratory results are to be extended to the field.

Beside cost of activity, respirometry can potentially provide direct evaluation on a host of other factors related to the energy budget of the shark. Depending on the conditions under which oxygen uptake is measured, energetics of food assimilation (i.e., specific dynamic action), aerobic metabolic scope, power performance curves, fatigue curves and cost of respiration per se can be detected (Bennett, 1978; Brett, 1970; Fry, 1971; Kleiber, 1975; Livingston, 1968). Finally, diel patterns of oxygen consumption can be obtained by maintaining the animal in the respirometer for periods of 24-48 h, and taking samples at constant intervals.

The energy budget of an organism consists of the temporal relations and magnitude of the inputs and outputs in the flow of energy through the animal. The sole input in the case of the shark is animal tissue from its prey; and the outputs are divided among several categories including assimilation, respiration, activity, reproductive products and ejecta (feces and urine). Growth represents storage of energy. My objective is to evaluate these parameters in the laboratory and extrapolate findings to the field with the dual goals of producing a conceptual model of the lemon shark (Fig. 1) and balancing its energy budget. The significance of this exercise is that I will be able to specify rate, amount and sources of energy this predator must remove from its environment to maintain itself at observed levels of activity and growth rates. This, in turn, is important because, as mentioned above, any balance sheet for flow of energy in the marine environment must identify the important sinks, sources and conversion efficiencies between them. Surely, the numerous sharks found in the bays, lagoons and reefs of the tropics represent a significant and presently unknown sink in the tropical marine ecosystem.

An annular respirometer (Fig. 10) has been constructed to conform to the average size of a juvenile lemon shark (70 cm - 2.0 kg). The dimensions of the respirometer provide a circular course of 400 cm^2 cross section and 238.8 cm linear distance from start to finish. This means that the average shark swims 3.4 body lengths to circumnavigate the course which contains 70.3 l of

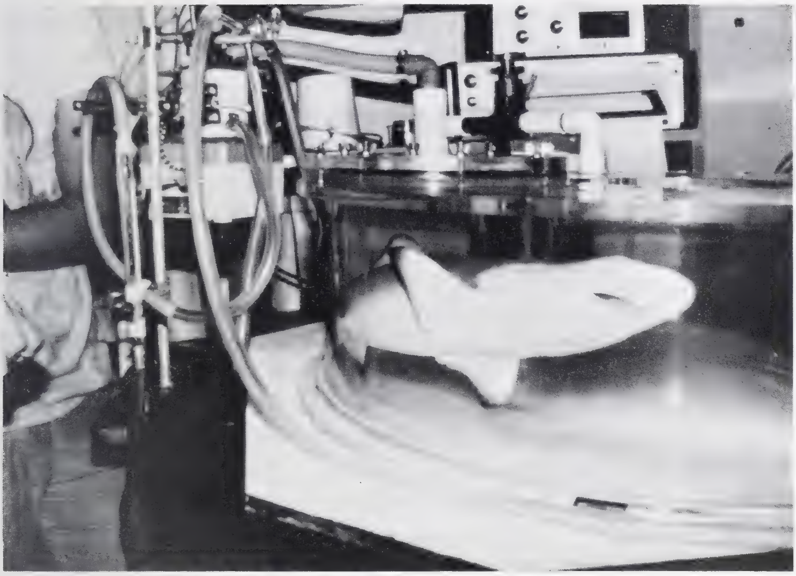

FIG. 10. Acrylic annular respirometer described in the text. A 68 cm TL lemon shark is shown within the respirometer.

water. The respirometer constructed of 9.5 mm thick transparent acrylic (Plexiglas) is connected to the shark's home tank, a 6,000 l aquarium (Gruber, 1980). Oxygen, salinity, temperature and microorganism content of this water are carefully controlled, and thus, biological oxygen demand has been found to be negligible. The basic system provides for continuous automatic measurement (on hard copy) of subsamples, so that successive comparisons can be made of the oxygen content of water entering and exiting the chamber. A variable flow rate of up to 25 $l.min^{-1}$ can be maintained and subsamples for Winkler titrations may be collected through a syringe permanently mounted on the chamber. Winkler titrations are used to confirm readings from a polarographic oxygen electrode. The chamber is fitted with a photoelectric switch so that as the shark breaks a light beam, its rate of swimming is recorded. We (Bushnell et al., in preparation) have thus measured swimming rates of up to 40 body lengths per minute. The design of the chamber and adaptability of the shark permit prolonged sessions of up to several days in the respirometer during which sharks are seen to eagerly feed on their usual food.

Routine metabolism, which approximates the metabolic cost of moderate activity in a free-swimming fish (Fry, 1971), was the first bioenergetic parameter evaluated in the respirometer. In practice we let the shark adjust its own rate of swimming during trials. However, this rate closely matched that found in unrestrained lemon sharks swimming in large tanks (see also Weihs et al., 1981). Unlike many sharks, lemons can lie on the bottom motionless except for gill and mouth movements used to pump water over their gills. Our measures of moderate activity include some "bottom time"; usually in the ratio of 15 min swimming to 1 min setting. We have measured routine metabolism at 22°C and 32°/$_{\infty}$ salinity for four sharks over a period of about 60 hr (Table 2). The average routine metabolism thus determined amounts to some 201 mg O_2 $kg^{-1}h^{-1}$. In two 30-min experiments we determined that the average oxygen consumption of 2 lemon sharks was 220 mgO_2 $kg^{-1}h^{-1}$. If this figure is confirmed, it will mean that lemon sharks are more efficient at extracting oxygen while underway than when resting on the bottom. This is not unexpected, and in fact, was predicted in Gruber (1980).

Establishing techniques for simultaneously recording oxygen consumption and blood gas parameters (see below for details) in active lemon sharks is the most important accomplishment in this phase of the program. Additionally, construction of a reliable respirometer and demonstration of its efficacy by obtaining repeatable and consistent measures of oxygen uptake in actively swimming lemon sharks was a significant advance. Finally, providing the first values for resting and routine metabolism in an active tropical shark (Table 2); and the second known value of oxygen uptake in any swimming shark (Piiper et al., 1977 reported the first) is of importance. In sum, as Brett and Blackburn (1978) noted ". . . it will be no small challenge to obtain systematic records on these more active members of the class Chondrichthys" (p. 280). With the establishment of these techniques, we have begun to meet this challenge.

Part II: BLOOD GAS PARAMETERS DURING EXERCISE. White (1978) has estimated that up to 40% of resting metabolism is consumed by respiratory mechanisms for extraction of oxygen from water. Gill efficiency and pumping sequences primarily determine this cost which has been evaluated in several shark species (Table 2). Poor extraction efficiency may limit scope for activity as has been shown for sharks of the genus *Scyliorhinus*. Scope for activity or aerobic metabolic scope is a measure of the maximum sustained energy available for such functions as pursuit, escape or courtship (Fry, 1971). One way to evaluate aerobic scope is to exercise an animal in a respirometer until oxygen consumption peaks (Brett, 1970). Another method is to measure blood gas parameters such as respiratory quotient, pO_2, pCO_2 pH and lactate during exercise. Decrease in pH as lactate accumulates signals onset of oxygen debt during which anaerobic substrates are called upon to provide energy (Hochachka and Somero, 1973).

To make such measurements, we (Bushnell et al., in preparation) have modified a surgical technique for implanting a cannula in the dorsal aorta of teleosts, first developed by Sovio and Oikari (1976). Figure 11 shows our surgical procedure. A shark can thus be cannulated in 15 min under tricaine anesthesia and rapidly recovers, often feeding the next day. Cannulas have remained in place for up to 80 da, during which blood samples were withdrawn from an unrestrained swimming shark with relative ease; the shark does not appear frightened or stressed when blood is taken.

TABLE 2. Routine metabolism of the lemon shark.

Date	Shark #	Wt (kg)	Temp (°C)	Sal (%)	Average Oxygen Consumption ($mgO_2 \bullet kg^{-1}h^{-1}$)	Range ($mgO_2 \bullet kg^{-1}h^{-1}$)	Duration of Experiment (less 6 hr acclimation time) (h)
2/28	01	2.0	22	31.0	238.7	152-341	4.5
3/3	01	2.0	22	31.0	232.9	157-298	3.5
3/5	01	2.0	22	31.0	178.1	115-270	3.5
7/16	02	1.7	23	32.4	140.0	107-151	3.0
7/25	02	1.7	24	31.8	165.0	106-217	4.5
8/7	03	2.7	25	36.0	256.9	169-346	4.0
8/8	04	2.0	22	32.0	198.2	129-270	4.5

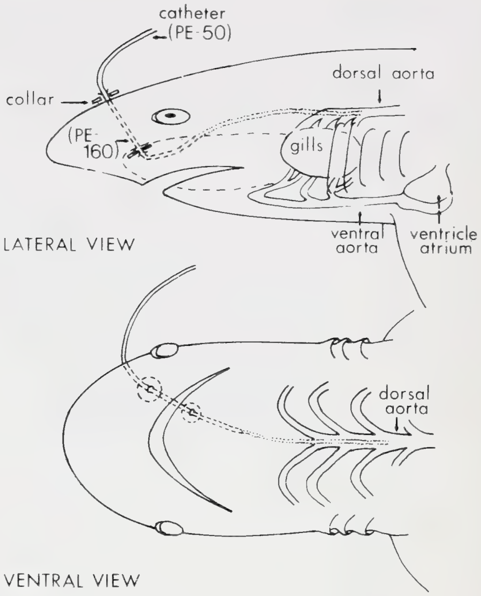

FIG. 11. Lateral and ventral aspect of the head of a lemon shark showing the aortic catheter in place. The catheter is inserted under the skin of the palate and gently forced posteriorly until blood fills the lumen of the plastic tube (PE-160). Thus, the catheter has entered the aorta. The catheter is then passed through the head and fixed in place with 2 plastic buttons (collar). Cannulated sharks have survived up to 80 da.

During the course of these investigations, we found that the circulatory system and blood of the lemon shark behave in some unusual and unexpected ways. First, most fishes and even mammals draw on the venous oxygen reserve which may fall from 40 to 20 torr during exercise. However, lemon sharks (but not dogfish or cat sharks, Table 3) apparently do not have a venous reserve. Where then do they get their oxygen from? Preliminary results indicate that during exercise the arterial blood gains some 40% more oxygen and the number of erythrocytes increases by 10%. One possible explanation for this increase lies in a putative gill shunt mechanism. Cook (1980) showed that 20% of the total respiratory exchange area in the gill of the shark *Centrophorus sculpratus* lay within a ventilatory dead space, thus providing a potential respiratory bypass shunt pathway. During exercise sphincters found in gill arch blood vessels (Wright, 1973) can presumably regulate blood going to the dead spaces. Such a mechanism may partially explain the increase in oxygen content found in the blood of the lemon shark. The overall implication is that lemon sharks have blood with a great affinity for oxygen. Their blood saturates at a very low partial pressure (30 torr). Similar partial pressures are found, for example, in burrowing animals, or fetuses (Schmidt-Nielsen, 1979). This means that lemon sharks can probably

TABLE 3. Arterial and venous partial pressures in sharks.

Species	Arterial pO_2	Venous pO_2	References
Negaprion brevirostris	28.7 ± 7	3.3 ± 1.5	Cannula; present study
N. brevirostris	27.5 ± 115	-	Puncture; present study
Scyliorhinus canicula	90-115	21-34	Puncture; present study
S. canicula	90.4		Butler and Taylor (1971)
Squalus suckleyi	85	10-13	Hanson and Johanson (1970)
S. suckleyi	69	8.1	Lenfant and Johanson (1966)
Scyliorhinus stellaris	49 ± 24	10 ± 2	Baumgarten-Schumann and Piiper (1968)
S. stellaris	81 ± 31	11 ± 9	Piiper and Schumann (1967)
S. stellaris	64 ± 11	8-12	Piiper, Mayer, Worth and Wilmer (1967)
S. stellaris	81	11	Piiper and Schumann (1964)

survive at low oxygen concentrations. Lemon sharks are often found in backwater areas near mangrove islands where organic matter accumulates, providing for high bacterial growth and low oxygen concentration. This unusually high affinity for oxygen may represent a special adaptation which allows this species to survive in such habitats. We plan to continue this work to elucidate more precisely the circulatory and respiratory adjustment of increased oxygen demand during exercise. Development of a ventral aortic cannula will permit monitoring of pre- and postbranchial oxygen tension during swimming.

Part III: INTAKE AND PRODUCTION. The remainder of the laboratory studies concern food intake, digestion, assimilation and growth of the juvenile lemon shark under controlled conditions. These basic studies must be done to estimate production levels. Yet, the best estimates of metabolic rates (of fish) in nature should be based upon laboratory experiments where subjects expend about as much energy, consume about as much food and grow about as fast as fish in nature (Davis and Warren, 1971). However, there is little information on fish and almost none for sharks on which to base such experiments. Thus these laboratory experiments for sharks will be performed and modified as information from the field accrues.

Food intake studies have been undertaken to establish the role of hunger and satiation in the shark's behavior; rates of feeding and their temporal variation; average meal size including coefficient of food utilization for growth (Winberg, 1956); and finally, rates of growth. All these parameters are being evaluated under controlled conditions. Measurement of gastric evacuation is a second study in which we (Shurdak and Gruber, in preparation) seek to understand the rate of digestion as an estimator of meal size, feeding rates and feeding periodicity (Fange and Grove, 1979). To determine caloric loss due to ejecta, feces and urine are being collected and these along with food combusted in a bomb calorimeter. Such data will provide information on energetic value of food, conversion efficiencies, total residence time of food in the gut, and loss of energy due to nitrogen metabolism and incomplete digestion. Thus all the elements for a rather complete laboratory evaluation of the energy budget will become available.

1. *Food intake.* We have completed a study of food consumption (Longval et al., this volume) in which 6 lemon sharks under controlled conditions were fed to satiation daily. The trial lasted 95 da during which the average shark (69.7 cm and 1745 g) consumed 47.4 g fish fillet daily and gained 867.2 g. Thus the shark consumed food equivalent to 2.72% of its body weight each day and increased its weight by about 50% in 95 da. This represents a coefficient of utilization for growth of 19% (Winberg, 1956), i.e., the shark converted 19% of its ration by weight into growth and storage. The rest, some 4,100 k cal was lost to the environment via metabolism or excretion. The study also showed that captive sharks have a cyclic rate of intake peaking every 4 da; and that their growth is similar to that of other young predators (Winberg, 1956).

2. *Digestion.* We have begun a study of digestion rates in captive lemon sharks by feeding predetermined wet weight of boneless bluerunner (*Caranx fuscus)* fillet. This is as close to a standard ration as the sharks will (presently) consume and so results represent a baseline against which we will compare other digestion rates for natural foods. By drying samples to constant weight we have determined that 73.7% of the fish fillet is composed of water. Preliminary calorimetry indicates that a 1 g dry sample releases approximately 4200 cal upon combustion in an adiabatic calorimeter. Food representing 2 to 3% body weight was fed to laboratory sharks, and stomachs were pumped at 3 h intervals for 24 h. Figure 12 shows the rate of digestion for 6 sharks (all over 80 cm and 3 kg); digestion is nearly complete in 24 h. Feeding these sharks large whole fish (*Lagodon rhomboides)* gives a very different result. Visualizing digestion by an x-ray technique (Molnar and Tolg, 1960) and later lavaging the stomach, we found digestion in progress even after 48 hr (Fig. 13).

3. *Growth.* Our 2 laboratory studies and results from tag returns indicate that the lemon shark grows slowly. This is in direct contradiction to published reports (e.g., Stevens, 1975). In the feeding study described above, the average lemon shark (69.7 cm) grew 0.53 $\mathrm{mm.d^{-1}}$ or 50.8 mm in 95 da. In the tag evaluation described earlier 36 sharks were held outside, in an open, flow-through system, during the summer months. The average shark (72 cm TL in this trial) feeding on whole steaks of Boston mackerel (*Scomber scomber)* grew 0.76 mm d^{-1} or a total of 68.2 mm in 89 da. Results from tag returns on 16 lemon sharks (72 cm average) showed an average growth of only 0.23 mm d^{-1} after an average of 110 da at liberty.

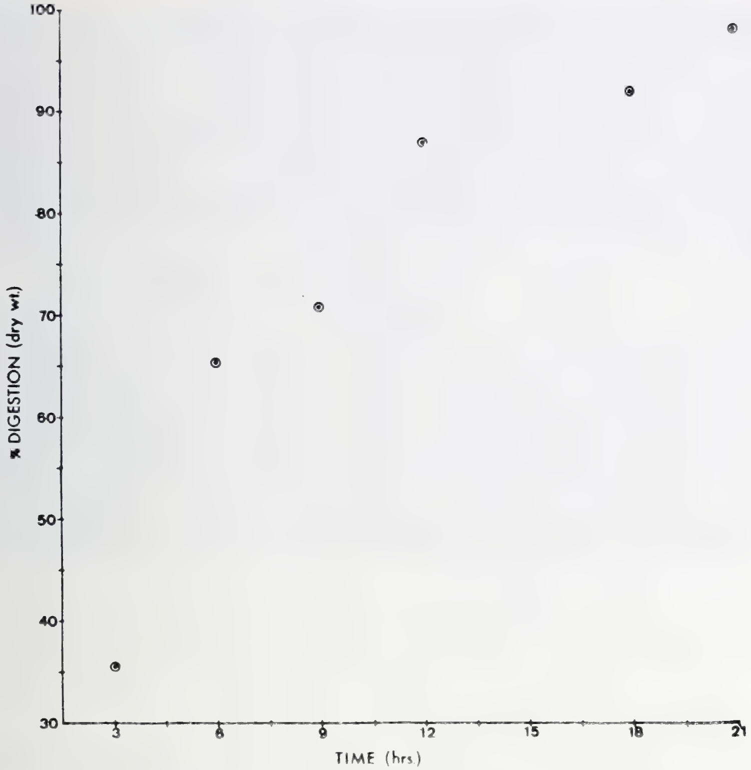

FIG. 12. Rate of digestion in the lemon shark. Points represent average data for 6 subjects (3.8 kg; 85 cm TL) held in a 6,000 l aquarium at 22°C and 32°/$_{00}$ salinity. Sharks were starved for 3 da and fed preweighed, boneless pieces of bluerunner fillet in the ratio of 2% body weight. They then had their stomachs pumped at 3 to 24 hr intervals. The recovered contents were reweighed and the difference converted into % digestion on a dry weight basis. Digestion of this protein ration is essentially complete after 24 hr.

Several points are clear from these comparisons: 1) even at the highest rate of 0.76 mm d^{-1} and assuming a constant growth rate, 6.45 yr would be required to reach 245 cm, the length Clark and von Schmidt (1965) report for sexual maturity; and 2) the lemon shark grows considerably more slowly than has been reported (i.e., 1-3 yr to maturity; Clark and von Schmidt, 1965; Moss, 1967; Springer, 1950; Stevens, 1975). Further support for our contention is gained by plotting a von Bertalanffy (1960) growth curve. Using a modification given by Holden (1974) and assuming a gestation period of 12 mo, length at 245 cm would require just over 7 yr which is close to our 6.45 yr estimate (Fig. 14). Thirdly, food is apparently limiting because laboratory sharks grow nearly 4 times faster than sharks at liberty. These laboratory results on feeding, digestion, calorimetry and growth represent the first such data for a tropical shark, and signal reasonable progress in understanding consumption, assimilation and production as related to the energy budget.

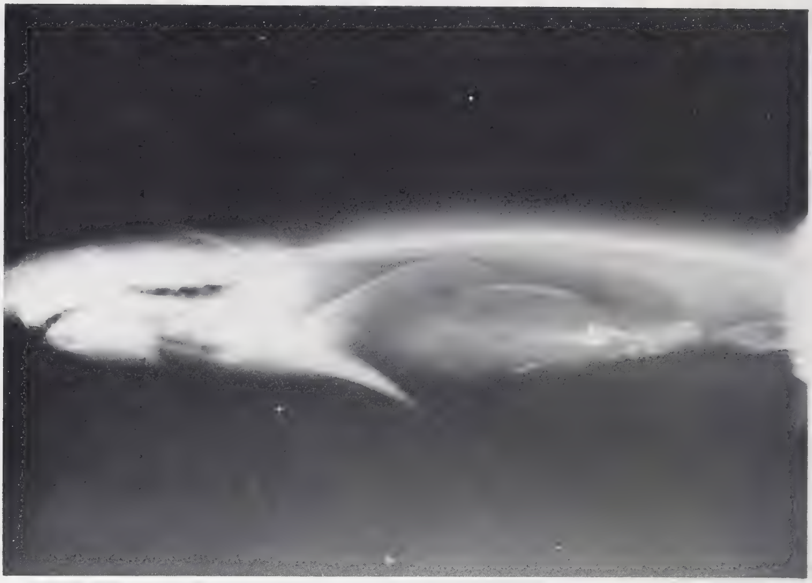

FIG. 13. X-ray positive print of a lemon shark showing remains of a whole pinfish (*Lagodon rhomboides*) fed to the shark 19 hr before the X-ray. A series of such X-ray photographs demonstrated that large meals of whole fish require at least 42 hr for complete digestion.

CONCLUDING REMARKS—Data presented in this paper clearly demonstrate the utility of the lemon shark as a model species in the ecological study of sharks. The characteristics of this species have permitted collection of behavioral, bioenergetic and physiological data both in the laboratory and field; these data confirm our prediction of the lemon shark as the species of choice. The results of this study, when integrated into a model for biological production will provide a representation of the lifestyle of the lemon shark which can serve as a standard of comparison with other species as future investigations are carried out. The information presented herein represents work accomplished in less than 2 yr. Since the symposium (spring, 1980) we have completed or are actively engaged in new experiments including: the marking and release of 250 more lemon sharks; the tracking of 3 more sharks; aerial survey of study sites using an ultralight aircraft; identification and calorimetric determination of prey items; circadian rhythm of activity and metabolism; age validation by counting vertebral rings and respiratory efficiency as well as power-performance studies. Several more experiments are in the planning stage. These include a detailed feeding study in which the amount and type of natural food is elucidated; then caloric values, assimilation efficiency and rate of digestion are determined in the laboratory. Hardware is concurrently being developed so that we can study the feeding event by remote telemetry. It is crucial to understand the frequency and timing of feeding to evaluate the lemon shark as a

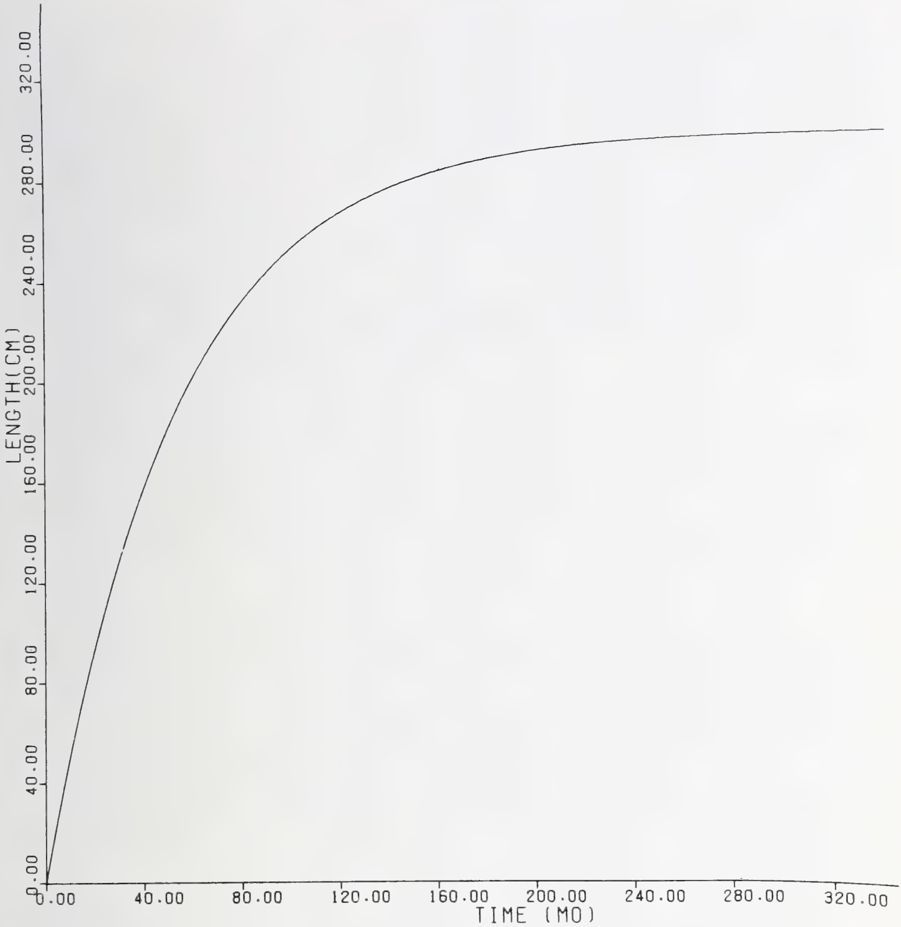

FIG. 14. VON Bertalanffy growth curve for the lemon shark, based on a gestation period of 12 mo, 60 cm total length at birth and a maximum size of 300 cm. Assuming maturity at 245 cm, the lemon shark requires 7 yr to become sexually active. This is close to our first approximation of 6.5 yr based on laboratory studies and tag returns.

predator. Finally we are developing data-logging devices to be used in conjunction with long-life ultrasonic transmitters. Such a system will allow the repeated and long-term observation of the behavior of a number of individual lemon sharks. This system takes advantage of the fact that young lemon sharks are fairly localized in the first few years of life.

While there is much work remaining to completely evaluate a conceptual model for the lemon shark, it is clear that we have made a good start and progress is continuing. If support for this work continues, we will complete the conceptual model and thus provide a significant advance in understanding the role of the shark in the tropical marine environment.

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SOME CHARACTERISTICS OF EXTINCT MAJOR GROUPS OF ANIMALS

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Abstract: *Twenty major groups of extinct animals with a good fossil record had some of the following characteristics. There is an uncommonly high percentage of suspension feeders and colonial animals. Most of the colonial animals were probably suspension feeders. Seventeen of these groups of animals were confined to a marine habitat and all were aquatic. None had a skeleton composed of silica. The skeletal material in these animals was calcareous, phosphatic, or chitinous, or some combination of these materials.*

Twenty groups of extinct animals (Table 1) were selected for examination of such attributes as type of skeletal material, habitat, whether colonial or solitary, and probable modes of feeding. Both vertebrates and invertebrates, over an extended geologic range, were considered (Table 2). The 20 groups chosen were selected primarily on the basis of diversity or large numbers of species. Some of these groups of animals were well-represented in many fossil faunas and were successful competitors for a considerable amount of geologic time. Certainly this was true for the trilobites, ammonites, graptolites, and rugose corals. Groups having only 1 or a few known species and genera were eliminated from consideration no matter how unique taxonomists have considered them to be. This particularly eliminates many extinct classes of echinoderms such as the Helicoplacoidea, Paracrinoidea, Parablastoidea, Edrioblastoidea, Homostelea, and several other small extinct classes. To have included most or all of these small extinct classes of echinoderms would most certainly have added to the number of marine, solitary, suspension feeders having calcium carbonate skeletons. Other small groups, such as the Heterocorallia, were also not considered.

Of the 20 extinct groups selected, all have been given at least the rank of subclass by some taxonomists. The 2 main sources for the data included in Tables 1 and 2 were the *Treatise on Invertebrate Paleontology* (1953-1975) and *The Fossil Record* (1967). Data on the Rostroconchia were taken from Pojeta and Runnegar (1976).

The skeletal material found in these 20 groups of animals consists of 3 basic chemical types—calcareous, phosphatic, and organic, usually referred to as chitinous. The skeletons of most of them very likely had a certain amount of organic material intermixed with calcareous and/or phosphatic compounds. Thirteen of the 20 groups had calcareous skeletons. In some instances the mineral was most likely calcite as in the Blastoidea, Edrioasteroidea, Stylophora, Rhombifera, Diploporita, and probably the

Table 1. The 20 extinct taxa indicating the type of skeleton (Ca-calcareous, P-phosphatic, Ch-chitinous), habitat (M-marine, F-freshwater), and solitary (S) or colonial (C) animals.

Taxa	Skeleton	Habitat	Solitary or Colonial
1. Archaeocyatha	Ca	M	S
2. Stromatoporoidea	Ca	M	C
3. Tabulata	Ca	M	C
4. Rugosa	Ca	M	S,C
5. Conulata	P,Ch	M	S
6. Cricoconarida	Ca	M	S
7. Calyptoptomatida	Ca	M	S
8. Rostroconchia	Ca	M	S
9. Ammonoidea	Ca	M	S
10. Trilobita	P,Ca,Ch	M	S
11. Eurypterida	Ch	F	S
12. Edrioasteroidea	Ca	M	S
13. Stylophora	Ca	M	S
14. Rhombifera	Ca	M	S
15. Diploporita	Ca	M	S
16. Blastoidea	Ca	M	S
17. Graptolithina	Ch	M	C
18. Conodontophorida	P	M	S
19. Acanthodii	P	M,F	S
20. Placodermi	P	M,F	S

Table 2. The 20 extinct taxa indicating which are invertebrate (I) or vertebrate (V) and the geologic range of each.

Taxa	Invertebrate or Vertebrate	Geologic Range
1. Archaeocyatha	I	Cambrian
2. Stromatoporoidea	I	Cambrian-Eocene
3. Tabulata	I	Ordovician-Permian
4. Rugosa	I	Ordovician-Permian
5. Conulata	I	Cambrian-Triassic
6. Cricoconarida	I	Ordovician-Devonian
7. Calyptoptomatida	I	Cambrian-Permian
8. Rostroconchia	I	Cambrian-Permian
9. Ammonoidea	I	Devonian-Cretaceous
10. Trilobita	I	Cambrian-Permian
11. Eurypterida	I	Ordovician-Permian
12. Edrioasteroidea	I	Cambrian-Pennsylvanian
13. Stylophora	I	Cambrian-Devonian
14. Rhombifera	I	Ordovician-Devonian
15. Diploporita	I	Ordovician-Devonian
16. Blastoidea	I	Silurian-Permian
17. Graptolithina	I	Cambrian-Mississippian
18. Conodontophorida	I	Cambrian-Triassic
19. Acanthodii	V	Silurian-Permian
20. Placodermi	V	Devonian-Mississippian

rugose corals. The main mineral in the Ammonoidea was probably aragonite. In the other groups with a calcareous skeleton, it is either not specified or uncertain whether the mineral was calcite or aragonite. The skeleton of trilobites consisted of a chitinous base with embedded calcareous and phosphatic materials. Phosphatic material occurred in the Conodonotophorida, Placodermi, Acanthodii, and Conulata. In the Conulata, a large amount of chitinous material was also present. Only chitinous or organic material occurred in the Graptolithina and Eurypterida.

It is notable that siliceous skeletons do not occur in any of these 20 groups. Siliceous skeletons are confined to some species of the 2 most primitive phyla at present, the Protozoa and Porifera. The question naturally arises as to why the higher animals do not use siliceous material in their skeletons, as it is both light and durable. The most likely reason is that once siliceous material is secreted it cannot be readily resorbed by the animal. Calcareous and phosphatic material can be readily resorbed by a living animal, and thus the skeleton can be modified during the ontogeny of the individual.

Seventeen (85%) of these 20 groups appear to be exclusively marine and all are aquatic (see Table 1). Some species of the Placodermi and Acanthodii apparently lived in fresh water, and the Eurypterida are thought to have lived in a fresh- or brackish-water habitat. The preponderance of marine groups may be caused in part by the fact that the fossil record is better for shallow-water marine animals than it is for either fresh-water or terrestrial animals (Nicol, 1977). But this does not completely explain the preponderance of strictly marine groups. Part of the explanation is that most of the early diversification of animal phyla and classes occurred in a marine habitat. Many of these animal groups were not preadapted to invade fresh water, much less a terrestrial habitat (Nicol, 1971).

The Graptolithina, Tabulata, and Stromatoporoidea were exclusively colonial animals, and some species of the Rugosa were also colonial. This is an unusually high number of colonial animal groups when it is noted that slightly less than 1.0% of all living species of animals are colonial (Nicol, 1978). However, I pointed out (Nicol, 1979) that a high percentage of colonial animals are sessile, benthic suspension feeders that secrete some kind of skeleton. Thus, the fossil record of colonial animals is far better than the fossil record for solitary animals.

Eighteen of the 20 groups of animals are invertebrates, and this is not unexpected when one considers that 97% of all living animal species are invertebrates and the percentage of invertebrate animals was probably even higher in the Early and Middle Paleozoic when all of these 20 animal groups arose.

The geological ranges of these 20 groups were taken mainly from the *Treatise on Invertebrate Paleontology* (1953-1975) or *The Fossil Record* (1967), and in a few instances there was not complete agreement as to the ranges of some of these groups. In these instances of disagreement, the more recent information as to the geologic range was most commonly used. Nine of these 20 groups first appeared during the Cambrian Period as shown in Table 2. Seven of the groups appeared during the Ordovician Period and only 2 each in the Silurian and Devonian. This proves that most of the basic differentiation of these 20 groups of animals occurred early—80% of it before the end of the Ordovician Period. One, the Archaeocyatha, did not survive the Cambrian. Four more became extinct during the Devonian Period, when quite a few small and archaic groups also disappeared. Two additional groups became extinct during the Mississippian Period and 1 in the Pennsylvanian Period. The greatest wave of extinction occurred during the Permian Period, when 8 of the remaining groups disappeared. Two more groups disappeared in the Triassic Period, 1 in the Cretaceous Period, and the last 1 during the Eocene Epoch.

The types of feeding that occurred in these 20 groups of animals is in some instances nearly certain on the basis of skeletal morphology and in others highly speculative. The 5 groups of extinct echinoderms were probably all suspension feeders. The Graptolithina, because of the small size of the individuals in the colony, were also likely suspension feeders (Nicol, 1979), and this is also probably true of the Stromatoporoidea. The Conodontophorida were probably suspension feeders because the denticles show no signs of wear and were apparently not used in feeding. The perforated structure of the walls of the Archaeocyatha makes it likely that these animals were also suspension feeders. Pojeta and Runnegar (1976) state that some of the Rostroconchia were deposit feeders, whereas other species of this group were suspension feeders. I am inclined to believe that all species of Rostroconchia were suspension feeders because of the thick and generally convex shell. They appear to be ill adapted for burrowing or plowing through soft sediments, as would be necessary for deposit feeders. Like their modern counterparts, the Scleractinia, the Rugosa may have been either carnivores or suspension feeders, depending on the type of tentacles. The Tabulata were probably suspension feeders, if the feeding habits of the octocorals are any criterion on which to judge. Thus, 12 of the 20 groups of animals may have been all, or in part, suspension feeders. As was pointed out in an earlier paper (Nicol, 1979), suspension-feeding animals appear to dominate fossil faunas, and this is caused by the fact that a higher than average number of them secrete skeletons.

It is most likely that the Ammonoidea, Placodermi, Acanthodii, and Eurypterida were scavengers or carnivores, and it is possible that the Cricoconarida were also scavengers or carnivores. The Conulata were possibly carnivores that captured their prey with their tentacles. The Trilobita may have been scavengers, detritus feeders, or even herbivores, but the kind of appendages that these primitive arthropods had gives no indication that they were predators. The feeding habits of the Calyptoptomatida are highly conjectural, and their morphology suggests that scavengers, detritus feeders, and herbivores are all possibilities.

ACKNOWLEDGMENT—I am indebted to Dr. Douglas S. Jones of the Geology Department at the University of Florida who read a draft of the manuscript and supplied helpful suggestions.

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FLORIDA SCIENTIST

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Biological Sciences

SEED DISPERSAL IN MELALEUCA QUINQUENERVIA

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ABSTRACT: *Wind dispersal characteristics of* Melaleuca quinquenervia *seeds were explored in laboratory and field investigations. Terminal velocities of free-falling seeds* (V_t) *ranged 0.45-1.75 m/s, but* V_t *for most seeds was approximately 1.2 m/s. Few seeds with* $V_t < 0.9$ *were viable, while the fastest classes had up to 92% germination. Seed density decreased logarithmically with distance from seed source. The distance of effective dispersal was within 15 times the height of the seed tree.* Melaleuca *seeds are held for years in closed capsules, but seedfall occurred in an undamaged stand throughout the 6 mo monitored. Herbicidal injections induced sudden massive seedfalls but the seed release rate remained above normal for 3 mo.*

THE migration or expansion of a tree population cannot be fully understood without knowledge of the dispersal characteristics of the species' propagules. Van der Pijl (1972) described the highly complex nature of seed dispersal, and Burrows (1973, 1975a, 1975b) constructed rigorous theoretical models to describe the flight of individual wind-dispersed seeds, with particular attention to turbulence effects.

I discuss seed dispersal of *Melaleuca quinquenervia* (Cav.) S. T. Blake (melaleuca or cajeput), a fast-growing myrtaceous tree from Australia that was introduced into Florida around 1900. *Melaleuca* naturalized in the wetlands of the southern third of Florida, and its uncontrolled expansion has created widespread concern for the region's indigenous ecosystems. To control this species, detailed information on its seed dispersal under varying conditions is needed.

Ripe *Melaleuca* seeds are held indefinitely within woody capsules. Seed release occurs when fire, frost, wind breakage, natural pruning, or human activities interrupt the continuity of the capsules' moisture supply, causing the capsule walls to dry and dehisce.

Melaleuca seeds are small (30,000/g) and vary in shape and size within a single capsule (Fig. 1). Capsule contents are not differentiated into fertile (seed) and infertile (chaff) components, as are capsule contents of the related eucalypts. Some shapes cause the seed to spin during flight and others merely to tumble. Because of this variability, the atmospheric buoyancy of the seeds must be assessed by some means other than size, weight, or form, especially when comparing them with other species' seeds. The ideal measure is terminal velocity, i.e., the velocity at which gravitational acceleration is balanced by air resistance.

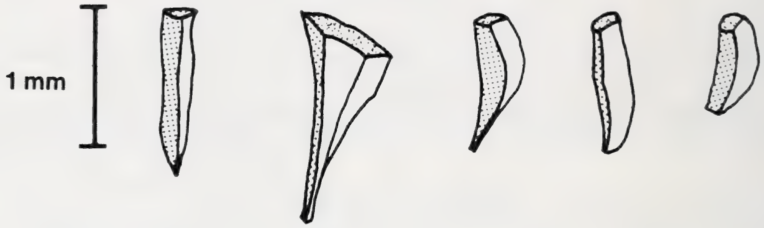

Fig. 1. A representative sample of *Melaleuca* seed shapes and sizes.

The terminal velocities of *Melaleuca* seeds in relation to germination percentages and seed weights, and a description of dispersal habits derived from seed-trap observations are reported herein.

Seven seed lots were analyzed: 2 mixtures from 5 and 6 trees, and 5 individual tree collections.

Wind Tunnel Method—A vertical wind tunnel was used to measure terminal velocities while separating seeds into various fractions for a germination test. The tunnel was a Dakota seed blower typically used for cleaning small seeds but modified for this study in 2 ways: the cylinder had no baffles disturbing the airstreams, and a thin cloth placed across the entrance of the tunnel encouraged equal velocities at all points of the airstream's cross section. Airstream velocity was measured with a vane-type Taylor air meter. This tunnel was a simplified version of Cremer's original device (Cremer, 1977).

All seeds ejected from the tunnel between 2 velocity control settings were collected. The prevalence of spinning seed was subjectively noted. The process was repeated, each time at a higher velocity, for a total of 6 increments with each seed lot. Each seed-lot fraction represented a range of terminal velocities, the extremes defined by the air-meter readings at the beginning and end of each increment. A sample of each fraction (100-300 seeds) was weighed. The resulting ratio of weight:count provided estimates of the number of seeds in each fraction. Fractions were subjected to a 20-da germination test (29.5°C, 16-h day, and 27.5°C night). One germination plate, containing 100-300 seeds, was used per fraction.

Free-fall Chamber Method—Average terminal velocities of the fractionated seeds were checked by a second method. A 3-m length of 20-cm stovepipe served as a free-fall chamber. Approximately 50-200 seeds from each fraction were held on a spatula and released instantaneously by lightly tapping the spatula against the pipe's upper edge. This simple method of release transferred no vertical motion to the seeds. Errors were easily perceived and resulting data rejected. The elapsed time of fall was manually measured with a stopwatch to the nearest 0.1 s by an observer at the bottom of the pipe and the process was replicated until the observer was confident of the timing. The timings were converted into terminal velocities without correcting for the acceleration phase of the fall. These average terminal velocities represented the seed fraction in subsequent regressions on seed weights and germination percentages.

In all field investigations, plastic culture plates, 9.5 × 9.5 cm, were generously coated with raw lanolin and used for seed traps. The traps were designed to be changed frequently. The trap was secured by an elastic cord drawn through holes melted into the sides of the plate and strapped to a thin piece of wood nailed to the end of a wood stake. The stakes were long enough to protrude above the ground cover and their tops were bevelled 15° to prevent water drops from remaining after rains. Trapped seeds were counted in the laboratory with the aid of a light table and low-power magnification. *Melaleuca* seeds were easily distinguished from debris or other seeds.

SPATIAL PATTERN OF SEEDFALL FROM ISOLATED TREES—Three single *Melaleuca* trees growing in abandoned agricultural fields were top killed by stem injections of herbicides; the resulting seedfall was monitored at 42 trap locations. Traps faced the tree and were placed along 6 equiangular lines radiating from the tree to distances of 5, 10, 20, 30, 45, and 65 m. Trees 1 and 2 had additional traps directly beneath the crowns at a 2-m distance. Traps were usually changed at 1-wk intervals. Data for wind velocity and direction observed every 3 h were obtained from the Fort Myers, Florida, station of the National Weather Service, 12 km from the study site. A total of 39 sets of traps was harvested from the 3 trees.

LONG-TERM SEEDFALL FROM UNDAMAGED TREES—Six seed traps were randomly placed in a dense, mature *Melaleuca* stand. Tree basal area outside bark (ob) exceeded 100 m^2/ha; stand density was 4600 trees/ha (stems > 5 cm in diameter at breast height, dbh); mean dbhob was 16.6 cm; and canopy height was ~20 m. No traumas, natural or artificial, occurred during the 26 wk of data collection. Traps were changed weekly.

RESPONSE OF SEED RELEASE TO HERBICIDAL INJURY—The onset and duration of increased seedfall caused by herbicidal application were studied in an open, uneven-aged *Melaleuca* stand growing on a pine/saw-palmetto/wiregrass site. One plot for each of 4 chemical treatments was installed with 9 traps in a 3 × 3 array at 3-m spacings surrounded closely by 15 or more treated trees. Three of the herbicides were stem-injected: Tordon 101R (picloram + 2,4-D), Banvel 720 (dicamba + 2,4-D), and Ammate (ammonium sulfamate). Bromacil was applied as a concentrated liquid to

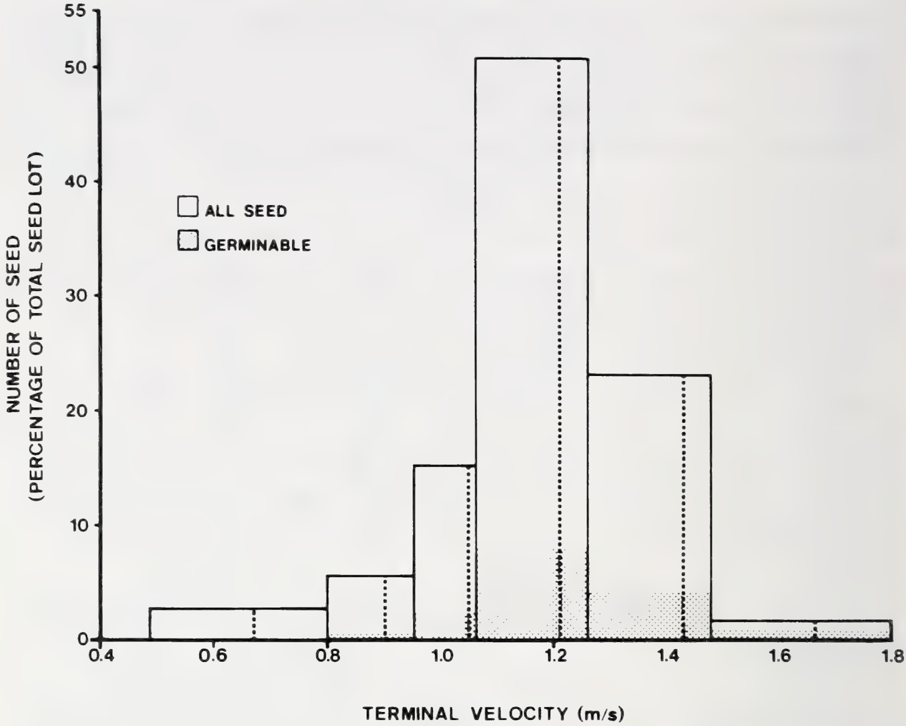

FIG. 2. Distribution of total and germinable seed among terminal velocity classes in a composit *Melaleuca* seed lot. Widths of histograms determined by airstream velocities in wind tunnel. Dashed line within each histogram indicates terminal velocity as determined by free-fall method.

the soil at the base of each tree. Treatments were applied 17 and 20 October 1978.

RESULTS—All seed lots exhibited a wide range of terminal velocities. Figure 2 shows the distribution of seeds among terminal velocity classes for the most representative seed lot (that collected from 6 trees). The distributions of total and germinable seeds were skewed in opposite directions due to the direct relationship between terminal velocity and germination percentage (Fig. 3). Among all seed lots, seed germinability was 0% for $V_t < 0.6$ m/s and no greater than 2% for $0.6 < V_t < 0.88$. With few exceptions, germination percentages increased rapidly as V_t increased beyond 1 m/s. However, the highest percentages (up to 92%) occurred in those fractions that contained a proportionately small number of seeds.

The correspondence between wind tunnel and free-fall estimates was strong. A simple linear regression of free-fall V_t on the midpoint of the corresponding wind tunnel range was unbiased, had an intercept of zero, a slope of 1.02, and a coefficient of determination of 0.91 ($n = 29$).

Terminal velocities determined by the free-fall method ranged 0.45-1.75 m/s. No single seed lot spanned this entire range; the mean range of in-

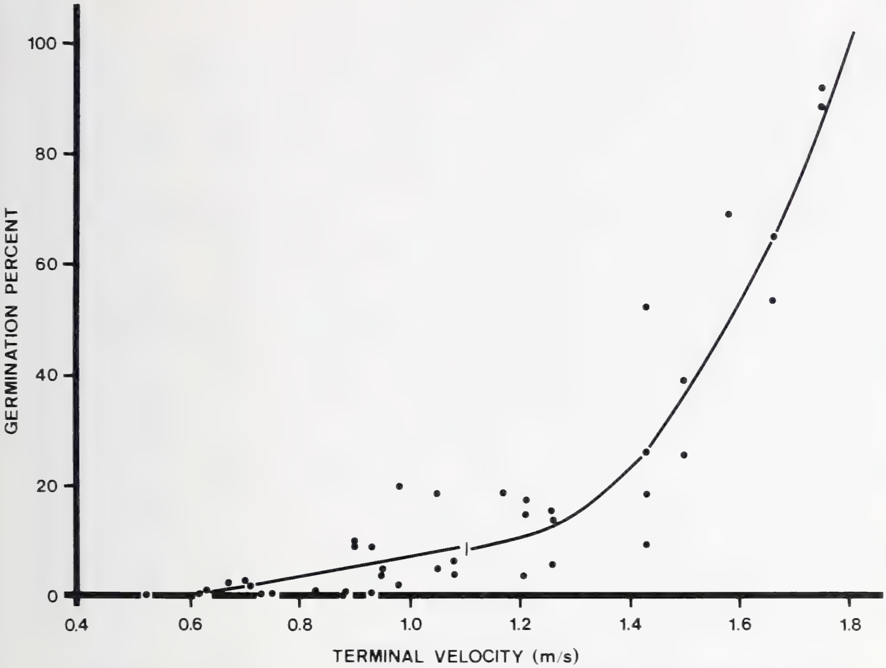

FIG. 3. *Melaleuca* seed germination capacity (GC) as a function of terminal velocities. Hybrid regression using all 41 fractions of all 7 seed lots. For $V_t \geq 1.08$ m/s (n = 20), GC = 266.6-457.4 V_t + 202.8 V_t^2 (R^2 = 0.87). For $V_t \leq 1.08$ m/s (n = 23), GC = $-11.1 + 17.9\ V_t$ (R^2 = 0.27).

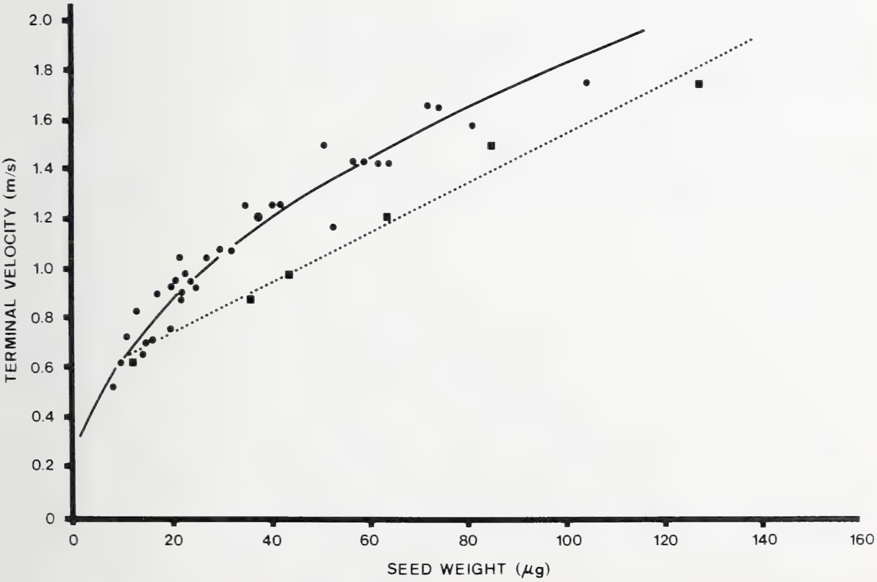

FIG. 4. *Melaleuca* seed terminal velocity as a function of seed weight (W_s). Solid squares and dotted regression line pertain to a single nonconforming seed lot. Among its fractions, V_t = 0.54 + 0.010W_s (R^2 = 0.98; n = 6). Among the fractions of the remaining 6 seed lots, V_t = 0.223 $W_s^{.458}$ (R^2 = 0.94; n = 35).

dividual seed lots was 1.0 m/s. The frequency distributions of V_t, based on either total or germinable seeds, had a mode at approximately 1.2 m/s. A pooled distribution for all 7 seed lots could not be determined because of inconsistent class widths. (A given control setting for the wind tunnel did not always produce the same airstream velocity.)

Regression analysis of terminal velocity on seed weight revealed a very strong curvilinear relationship ($r = +0.97$ using a log-log transformation) when 1 seed lot from a single tree collection was excluded (Fig. 4). The strength of the linear relationship among fractions of the latter indicates that the nonconformity of that seed lot was real and not the result of experimental error. Most probably, seeds from that tree had a higher air resistance due to a difference in shape that affected their spin. Every fraction of all seed lots was dominated by spinning seeds. However, the rate of spin and the location of the rotational axis varied noticeably, both within and among fractions.

SPATIAL PATTERNS—Seeds were caught by even the most distant (65 m) traps. Seedfall density declined logarithmically with distance from the seed tree (Fig. 5), and traps at 65 m typically caught 0 or 1 seed. The maximum number of seeds caught by a trap at that distance was 32; the next largest catch was 23 and occurred once with each of 2 trees.

Of the 39 sets of traps installed, 17 caught too few seeds to reveal any meaningful pattern while 27 provided usable data. Results of 3 sets are in Fig. 6.

Seed deposition patterns coincided with wind patterns observed at the weather station. As expected, the greatest total number of seeds were caught, and at the greatest distance, downwind of the prevailing winds. Continuous wind records were not needed to predict the seed deposition pattern; the 3-hourly observations adequately characterized the strength and direction of the prevailing winds. When high-velocity winds of short duration occurred, they either blew in the direction of prevailing winds or failed to disperse a disproportionately large number of seeds. In general, the 60° wind sector(s) with the highest frequency of observations also had the strongest winds. As a consequence, the frequency of a wind direction was a more useful predictor than was the mean or maximum velocity in that direction. The directional velocity became less important for seed deposition periods longer than 1 wk: Fig. 7 shows the homogeneity of windspeed data summarized for 2 mo and, in contrast, the strong correspondence of directional frequency and seed deposition.

SEEDFALL FROM UNDAMAGED TREES—Seedfall occurred throughout the 6 mo study period (Fig. 8). Seedfall was considerably higher and more variable in the summer and early fall than in the late fall and early winter, although the differences were not significant. The weekly seedfall in this closed stand, based on a minimum median value of 20 seeds/trap/wk, was 2260/m^2.

SEED RELEASE AFTER HERBICIDAL INJURY—Seed release accelerated quickly after treatment with either Tordon or Banvel, peaking at 2 wk. However,

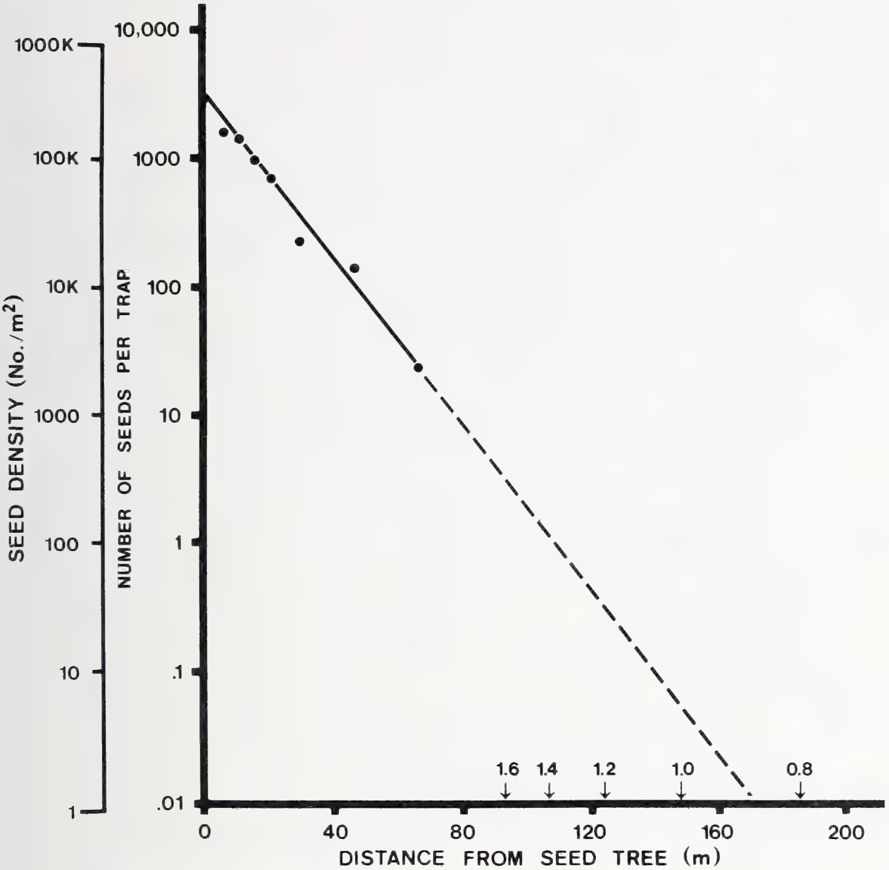

FIG. 5. Seed deposition from 12-m tree along single trapline during 1 wk with maximum recorded windspeed of 12 knots (6.18 m/s) and mean windspeed of 7.7 knots (3.97 m/s). An arrow indicates the calculated distance seeds with the superimposed value of V_t would travel, given: $D = 2(6.18 \cdot 12/V_t)$.

seed release remained well above the base level for an additional 10 wk (Fig. 9). (In a separate study, seed release from 250 trees injected with Tordon in the closed stand referred to above also peaked at 2 wk and the rate of release did not return to the base level for 3 mo.) Bromacil was just beginning to yellow leaves 16 wk after treatment; after 32 wk, most capsules were still closed, even on trees that had been fully defoliated weeks before and which were expected to die eventually from the herbicide. The Ammate treatment failed to cause even defoliation and therefore had no effect on seed release. Seedfall on the Ammate plot was relatively steady for 18 wk and was very close to the mean rate on all 4 plots the week before they were treated (2.6 seeds/trap/day). Therefore, the equivalent value of 2007 seeds/m^2/wk is taken as the base level seed deposition rate for this open-grown stand.

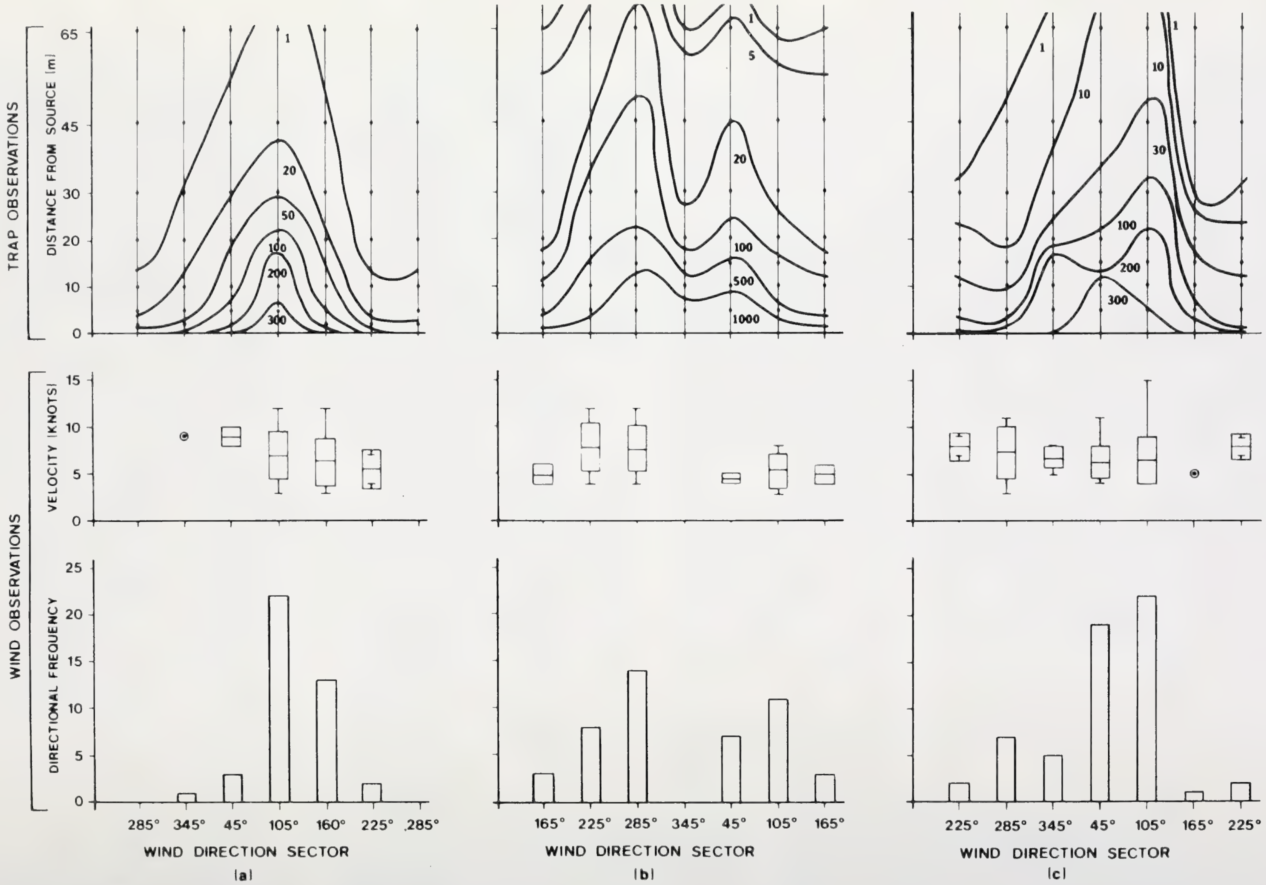

FIG. 6a-c. Three examples of seed deposition, shown in relation to wind velocity and frequency of wind direction. Each example relates to a 7-day trap exposure. Upper graphs show isopleths of seed • trap^{-1} • week^{-1}. Radiating traplines are here shown as parallel lines above corresponding wind sector midpoints. Box plots in middle graphs show mean windspeed in a given wind sector, the single standard deviation interval, and the minimum and maximum observations.

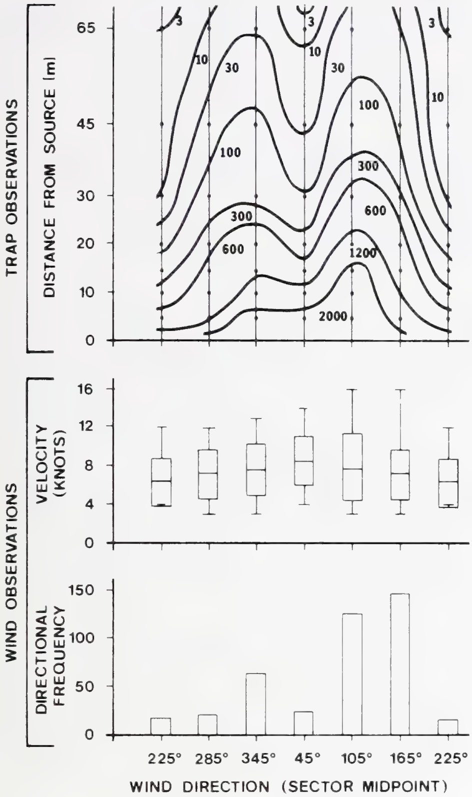

FIG. 7. Pattern of total seed deposition from Tree 3 for 2 mo after injection. Format is identical to Fig. 6.

DISPERSAL DISTANCE—*Melaleuca* seeds had high terminal velocities relative to other wind-dispersed seeds of similar size class. Even the much larger (winged) seeds of *Casuarina glauca* and *Pinus elliottii* var. *densa* fell more slowly than *Melaleuca* seeds. In a separate study, the mean V_t of individually timed *Casuarina* seeds was 0.99 m/s with a s.d. of 0.49 and a mode of 0.76 m/s (n = 303); for *Pinus*, mean V_t was 0.91 m/s with a s.d. of 0.45 and a mode of 0.93 m/s (n = 100). Most discussions of seeds that are kept suspended by vertical components of frictional or thermal turbulence are based on seeds with terminal velocities less than 0.3 m/s. Most pollens and spores have terminal velocities less than 0.1 m/s (Burrows, 1975a).

Turbulence is an important force in the dispersal of seeds and becomes particularly important at high windspeeds. However, the calculation of turbulence requires certain windspeed data that are rarely available. A simple doubling of dispersal distances predicted by the following idealized formula

(Cremer, 1977) approximately compensates for the missing turbulence factor:

$$D = U \cdot H / V_t$$

where D = horizontal distance of seed flight (m)
H = height of release (m)
U = mean windspeed (m/s) at 0.5H
V_t = terminal seed velocity (m/s)

The 2× turbulence correction was suggested by the relationship expressed in Fig. 5. Extrapolation of the logarithmic decrease in seed density in this example predicted that a density of at least 1 seed/m^2 would not occur beyond 180 m from the seed source (15 times the height of the tree). The above formula (corrected) predicted a similar dispersal distance for the lightest seeds, assuming an effective wind of the maximum observed velocity (12 knots or 6.18 m/s) and a release point at the very top of the tree (12 m). The trap data in Fig. 5 came from 1 wk with relatively heavy seedfall, and with a particularly high seed count at the most distant location on the one trap line shown.

Most *Melaleuca* trees, especially open-grown ones, are less than 20 m tall; most of the variable seeds have a terminal velocity of 1.2 m/s; and most seeds are released into winds with speeds of only 5-10 knots (2.6-5.1 m/s). (Three facts give support to this windspeed assumption: light winds are the

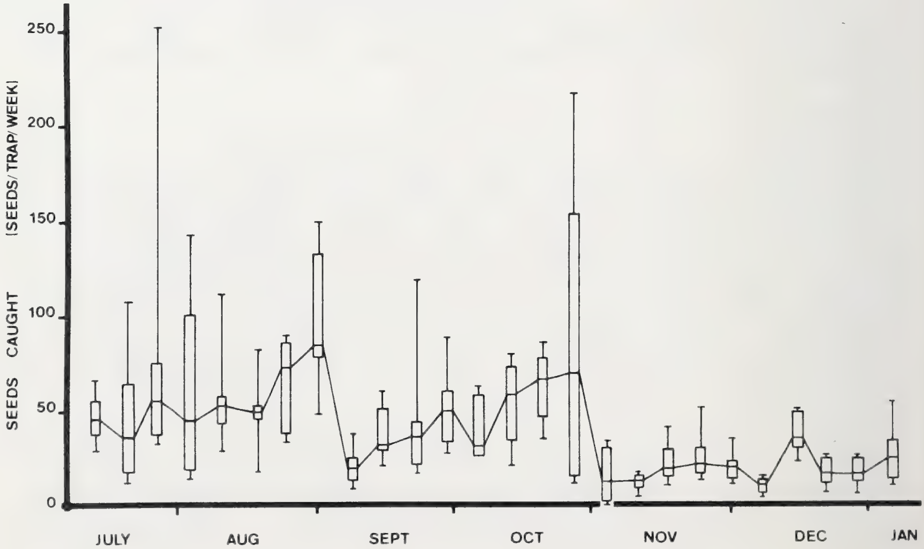

FIG. 8. Seed deposition measured by 6 traps in an undamaged, closed *Melaleuca* stand. The central point on each box plot is the average of 2 traps. The 4 other points represent individual traps.

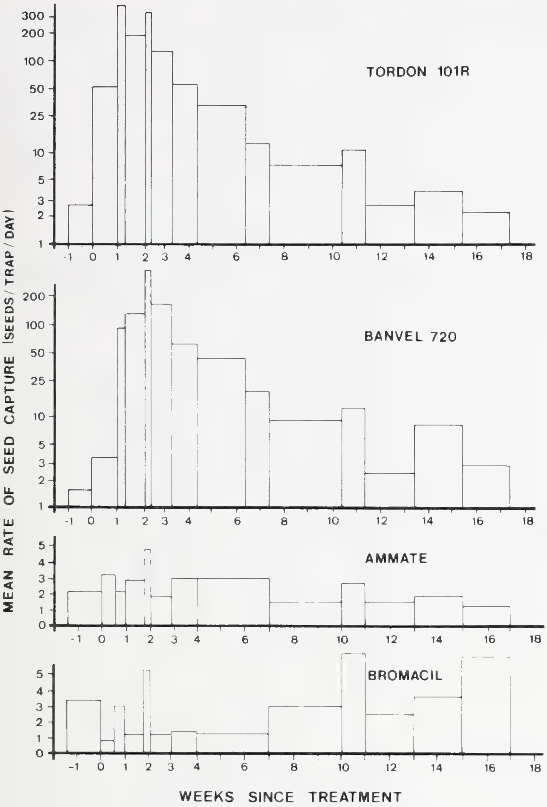

Fig. 9. Seedfall as response to herbicidal injury. Width of histogram indicates duration of trap exposure. Ordinate scales are logarithmic for Tordon and Banvel.

most frequent; light winds can shake branches sufficiently to empty most open capsules; and capsule dehiscence is only weakly dependent on weather conditions.) Therefore, under average conditions, most seeds will be dispersed no farther than 8.5 times the height of the seed source, which means, in most cases, no farther than 170 m.

Dispersal direction—The importance of prevailing winds in determining the shape of a seedfall pattern was a significant finding. Before this study, the assumption was that seed are shaken free of their capsules primarily during violent winds; furthermore, it was assumed that in south Florida those strong winds are of such brief duration, and have directions so unpredictable, that the coarse wind data used in this study would not sample them adequately. The results, however, suggest that the location of critical concentrations of seeds are predictable from wind data that are readily available from every permanent National Weather Service installation.

A comment is required on the method of presenting data in Fig. 6a-c. The spatial distortions of transforming radiating trap lines into parallel lines yielded several advantages: curve fitting was less arbitrary; minor differences among trap lines were accentuated; the larger the area sampled by a given trap, the less visual prominence its datum was given; and the presentation of wind data was not as constrained as it would be with wind roses.

Timing of seed release—The relationship of seed release to herbicidal injury was indirect. Capsules did not dehisce unless the branch supporting them died; the key mechanism was the interruption of the water supply. Therefore, the mode of action of a herbicide, as well as its efficacy, determines the timing of seed release. For most root-absorbed herbicides, e.g., bromacil, the death of vascular tissue follows a period of gradual starvation lasting sometimes over a year. Many other herbicides, e.g., Tordon and Banvel, have a more immediate effect.

One suggestion for controlling the spread of *Melaleuca* populations has been to kill the seed trees herbicidally at a time when environmental conditions would prevent establishment from the seeds consequently released. However, the longer the period of increased seedfall, the greater the chances that favorable site conditions will return and thus the opportunity for destroying all seeds will be lost. A duration of increased seedfall shorter than the 3 mo seen with the Tordon treatment is unlikely: the treatment gave complete top kills of all 16 trees within 1 mo.

Injury is not the only ecologically important mechanism for seed release. Assuming that 15% of the seed were viable, a base level of 339 and 301 good seed per square meter fell every week in the respectively closed and open stands investigated in this study. This viability assumption would be in serious error if the trapped seed were mostly old, deteriorated, and no longer germinable. However, I have confirmed Meskimen's (1962) finding that a 15% germination percentage can be maintained by even the oldest capsules found on large old trees. Furthermore, seed release from undamaged trees is primarily the result of self-pruning due to shade, and branches thus pruned do not necessarily bear the oldest seeds on the tree. Self-pruning is a result of competition among branches, the competition being most intense during periods of rapid growth. The seasonal differences in the seed release rate in the closed stand (Fig. 8) correlate well with data of the only growth parameter measured in that same stand: The monthly growth in stem circumference, as determined by 8 trees with dendrometer bands, was twice as high from April through September as in any other month.

Melaleuca often grows on sites that flood in summer. Flooding does not inhibit growth in this species. Therefore, some seed inevitably falls during flooded periods. Fresh *Melaleuca* seeds resist wetting and can rest atop the surface-tension film for days. Dispersal by water currents was not studied, but may in very special—and limited—circumstances transport seeds farther than wind dispersal.

The phenomenon of seed release after fire damage also was not studied. A highly variable relationship is believed to exist. In contrast to the relatively slow stimulation of herbicides, a hot crown fire causes complete capsule dehiscence in a matter of days, not weeks. Only a minor percentage of seeds are consumed by these crown fires, which are too fast-moving and irregular to produce an internal temperature in every capsule that is lethal to the seeds. In contrast, "cool" ground fires may pass beneath *Melaleuca* crowns without even scorching leaves in the seed-bearing trees. In both cases, the seedbed is prepared and a fresh seed input follows, even though seed release is not directly triggered in the latter case.

Because seed retention extends beyond seed ripening, *Melaleuca* has 2 distinct reproduction possibilities. First, a virtually continuous, although low-level, seed release ensures that some of the seed lying on the ground near the tree will be fresh, which allows the species to exploit all reproduction opportunities—no matter how short in duration. Second, the retention of several years' seed production allows for a particularly heavy seedfall if some natural catastrophe kills advance reproduction along with seed trees.

In conclusion, *Melaleuca* seed is adapted to a medium distance dispersal, which saturates areas immediately adjacent to the seed tree. The seeds do not seem to show adaptations for wind transport. However, strong winds could occasionally carry seeds more than a kilometer (Schroeder and Browder, 1979), depositing them in a microhabitat perhaps conducive to establishment. Such events are probably rare but their effectiveness in creating new centers of invasion is indisputable.

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Social Sciences

COLONIZATION AND THE TROPICAL ECOSYSTEM OF BOLIVIA

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ABSTRACT: *The demise of the tropical rain forest of Amazonia is proceeding as a result of frontier expansion by every country which borders on the Basin. In Bolivia, settlement of the humid lowlands is viewed as a solution to population pressures in the mountain regions and has been encouraged by government programs. As a result of the exigencies of traditional horticulture, the settler is locked into a system of shifting production. Normally under low density populations this system permits forest regeneration. In actuality, shifting horticulture is occurring under situations of high density population which when linked to mechanized agriculture frequently results in the conversion of forest tracts to grasslands.*

FOR those Latin American countries which include portions of the Amazon basin within their boundaries, development of this vast wilderness area has become a national imperative. The crowded coastal areas of Brazil, the demographic pressures of the Andean nations, a disenfranchised and poverty-stricken peasantry have all contributed to the prevalent belief that the Amazon represents a panacea for the socioeconomic ills of much of South America. The eagerness of governments and multinational corporations to exploit this territory has been met by a relatively ineffective counter offensive to moderate, control, direct or even halt the changes which are now taking place. Researchers such as Davis (1977), Holmberg (1950), Brooks (1973) and others have documented the apparently inevitable cultural extinction of Amazonian aboriginals. Meggers (1971), Denevan (1973), Woodwell (1978), and Gomez-Pompa (1972) are only a few of the scholars who have contributed knowledge and speculation on the agricultural potential (or lack of it) of the Amazon Basin and the effects which massive clearing of forest canopy may have on the world environment. It is unfortunate, however, that most efforts to present alternatives to the total destruction of this great wilderness have gone unheeded by those who have the power to halt the process. Part of the problem lies in the fact that most of the Third World has little else to exploit but its unrenewable natural resources. To the unstable governments now in power in the regions encompassing the Amazon, short-term benefits look very good. Then too, the U.S. did precisely the same thing in its expansion into the western territories. It is rather chilling to reflect on the parallels between both cases. Our perhaps overly romanticized history of "How the West was Won" has in itself been a great incentive to try it again in Brazil, or Venezuela, or Bolivia. In a way, one must sympathize with those governments which ask why they are to be denied their only chance at a great frontier expansion. The probability that it indeed may be a "counterfeit paradise," to borrow from Meggers, is hard to believe when one is mining for gold, cutting down huge mahogany trees, staking out a cattle ranch, or cropping rice.

The focal point of what is occurring in the Amazon frequently has been Brazil, the largest of the South American countries and the one with the greatest percentage of Amazonia within its national domain. We would be fortunate in many ways if the entire Amazon Basin were located within the boundaries of one country. Perhaps a more concerted effort could then be made by scholars and the world community to mitigate the negative effects of expansion. But the fact remains that in addition to Brazil, French Guiana, Surinam, Guyana, Venezuela, Colombia, Ecuador, Peru, Bolivia and Paraguay also claim what ultimately is a significant chunk of Amazonia. Unfortunately, just as the scientific community does not normally deal with any one of these countries as an "Amazonian nation" neither do the countries themselves. There is little concern among the Andean nations for example, that their movement toward the east is contributing to the ultimate demise of an entire ecosystem.

Bolivia and Amazonian Development—A case in point is the on-going effort to open for development the eastern region of Bolivia, or the *Oriente* as it is known. This process began in earnest in the late 1950s, following the Social Revolution of 1952 and the Agrarian Reform law a year later. The nationalization of mining operations and the expropriation of hacienda lands resulted in some unexpected negative repercussions. The mines soon found themselves in economic trouble due to poor administrative policies and rapidly expanding labor roles (Zondag, 1968). The redistribution of land to the peasantry brought about severe minifundia in certain sectors of the nation. In the Cochabama Valley the average peasant received less than 1.8 ha of farm land (Zondag, 1968). In an effort to diminish demographic pressures in the highlands, the Bolivian government secured international loans to begin an expansion program in the *Oriente.* Roads were constructed and several ambitious colonization programs were initiated to open lands for settlement by highlanders.

Since the early 1960s, there have been numerous studies completed by agencies and individuals in an attempt to assess the relative success or failure of colonization schemes in Bolivia (Henkel, 1978; Wiggins, 1976; Stearman, 1973 and 1978). These projects have been evaluated in terms of administrative policies and management practices, the quality of available infrastructure, social and physical problems of adaptation experienced by the colonists, and most importantly, whether settlers remain permanently in the colony. As might be surmized, one of the greatest problems encountered in all of these colonization projects is that of excessively high abandonment rates, averaging over 40%, but going much higher during initial settlement periods. Much of the frustration experienced by agency personnel working to stabilize populations in new land settlements can be attributed to a lack of understanding of the true role colonization plays in lowland frontier expansion. My research in the *Oriente* indicates that colonization is only an intermediary stage in Amazonian development, and to expect the majority of settlers to remain permanently in these areas is a contradiction of the expansion process itself. Colonization in most instances is simply a catalyst which precipitates a series of events which are soon beyond the control of the settler and ultimately even beyond control of the agency which is involved.

Current Land Use Patterns—In Bolivia, land allotments to colonists have ranged 10-50 ha. The smaller allotments were increased after it was realized that parcel size contributed to population instability. Those settlers with only 10-20 ha of land very quickly used up their virgin forest and found themselves caught in what Maxwell (1979) aptly terms the "barbecho (second-growth) crisis." The Bolivian *Oriente* is somewhat more fortunate than much of the Amazon area in that it comprehends a large alluvial plain between the Andes to the west and the Brazilian shield to the east. Hence, the soils are heavier and more suited to agriculture than is typical for much of the Basin. Nonetheless, fertility rates do drop significantly after 2 yr of cropping, and fertilizer is prohibitive in cost to most farmers. Lack of soil fertility, however, is not the major cause for abandonment of farmland. Once the forest cover has been removed, weeds and shrubs are quick to take advantage of the open space. This second growth is what the Bolivian calls "barbecho", and what he finds himself technologically incapable of combatting. Using traditional methods of slash and burn horticulture, the peasant is soon overcome by weed invasions which sap the strength from his crops and which require continual labor to control. Within a short time, the cultivation of barbecho land simply does not pay. Even worse, because there are large grasslands in some areas of eastern Bolivia, it is likely that grass eventually will invade the colonists' cleared land, rendering any subsequent traditional farming an impossibility. There are effectively 2 avenues of escape: first, convert to mechanization which, for a time at least, makes farming barbecho cost effective; or second, let the grass encroach or plant pasture and gradually convert to beef or dairy cattle. Because there is little thought to rotating crops and thus conserving fertility, much of the land presently under plow will eventually end up as pasture as a last ditch effort to make the land commercially viable. It should also be noted that either avenue requires substantial capitalization. Machinery and livestock both represent significant financial investments for the peasant who finds himself faced with the barbecho crisis. If his parcel size is 50 ha, the crisis will be postponed a bit but inevitably will come. Those few colonists who have been successful in managing their affairs find themselves able to make the necessary investments to move on to the next agricultural stage—mechanization, cattle or a combination of both. Those who are not so fortunate must abandon their land to go even farther to search for new wilderness. The "worthless" land they leave behind is quickly acquired by their more successful neighbors who consolidate it into their own holdings. Both cattle ranching and mechanized agriculture require land extensive operations to be cost effective.

For most colonists, then, their future as small farmers is locked into shifting agriculture. Without capital to meet the barbecho crisis, most settlers move on to cut down more virgin forest, crop it for a few years and then sell out to those who can mechanize or buy livestock.

The instability of market prices for crops has also contributed to the overwhelming desire of all agriculturalists, small and large, to go into cattle. Meat prices are continually on the rise and there remains a shortage of milk and milk products. Cattle are seen as a bank account, money on the hoof, savings which will not disappear because of late rains, insects, low prices, no transportation, no storage facilities or lack of harvest labor. Thus, while the colonist clears land for crops, he, or more likely, those who come after him ultimately are interested in ranching.

Because the *Oriente* still holds hundreds of thousands of hectares of wilderness there is very little concern about making the best use of the land presently under cultivation or in pasture. As previously mentioned, crop rotation is virtually unknown because there are few nitrogen-fixing crops which have market value in Bolivia. Soybeans show promise, but because they are not a crop which is conducive to hand harvesting they offer little hope for the small farmer. A good example of typical land use practices in lowland Bolivia is the cotton boom of the 1970s which created a wasteland of large areas in the department of Santa Cruz. Monocropping cotton on extensive contiguous fields recreated the same ecological disaster which occurred in the San Joaquin valley near Bakersfield, California in the late 1960s (Rodale, 1972). New strains of pesticide-resistant insects developed which could not be controlled. In the Bolivian situation, however, the land was simply abandoned, an economic impossibility in California where new technology came to the rescue. In 1975, Bolivia was cropping cotton on 60,000 ha of land. As of 1978 this had dropped to less than 31,000 ha (Cordecruz, 1979). Much of this land has now been devastated by severe wind erosion, a continual and growing problem in the southern region of the *Oriente*. Wind erosion is not normally associated with humid tropical regions. The southern region of Santa Cruz, however, is a transitional zone, bordering on the flat, dry *chaco* of Argentina and Paraguay. Strong winds continually blow into Santa Cruz, raising dust storms and generally making life miserable for everyone for days at a time. This condition has given rise to nicknaming the capital city, Santa Cruz de la Sierra (Santa Cruz of the Mountains), Santa Cruz de la Tierra (Santa Cruz of the Dirt). As one travels farther north, the forest acts as a windbreak, countering the erosion. As more land is cleared, erosion increases and the winds begin to reach into areas formerly safe from their scouring force. During my interviews with elderly farmers of Santa Cruz, they consistently indicated that 30-40 yr ago the forest extended much farther south, giving rise to the suspicion that the Chaco desert is moving north.

FOREST TO PASTURE—In terms of its forest resources, Bolivia has followed other nations in setting aside by legislative decree (Cordecruz, 1979) certain portions of forest designated as reserves. These national forests are subject to exploitation, however, through the ceding of cutting rights to individuals or corporations. The illegal extraction of wood from forest reserves is also a problem due to the government's inability to police these areas.

The cutting of hardwoods is a selective process which does not have as a result the immediate ecological and esthetic damage created by clear-cutting single-species forests found in temperate climates. Nevertheless, the long-term damage may be just as devastating. First, reforestation programs in Bolivia remain in an experimental stage and attempts to replant hardwoods are insignificant when compared to extraction rates. Second, hardwoods such as mahogany do not grow in stands, but are sparsely distributed with perhaps as few as 3 mature trees per square kilometer. As a result, natural reseeding occurs on a limited basis. In addition, most species of hardwoods are not adapted to disturbance conditions and their seeds do not possess qualities for long-range dispersal (Gomez-Pompa, et al., 1972). Thus, there is a growing fear that many hardwoods may disappear. Finally, it is the side effects of logging which ultimately spell doom for virgin forests. The cutting of valuable hardwoods depletes the forest of this commodity and may eventually bring about the extinction of certain species. Even so, the majority of the forest is left standing. But once a logging trail is cut and trucks or other means of transport are able to penetrate the wilderness, it is not long before spontaneous settlers take advantage of available land.

COLONIZATION AND REAL POLITIK—In effect, these spontaneous colonists have no legal right to be on the land they are clearing for crops. To date, the Bolivian government has been unable, and to some degree unwilling to prevent these invasions. The attitude of most officials is that the wilderness is there to convert to cropland and pasture. If colonists want to do this work on their own initiative, it simply saves future cattle ranchers the time and cost of land-clearing.

Once a large tract of land has been colonized by numerous settlers, the density of this population precludes any further thought of trying to remove them. This type of land invasion and subsequent government inability to deal with *de facto* settlements has many precedents, both rural and urban. Probably the best known case in the United States was the illegal settlement of land in Oklahoma by pioneers who became known as "Sooners," people who in order to gain choice locations invaded government land before it was legally opened to settlers. In Lima, Peru, Mangin (1970), Turner (1970) and others have described the process whereby urban migrants move onto government or private land on the outskirts of the city and claim squatter's rights. For any government in these situations, the removal of illegal settlers becomes politically untenable and the squatters are allowed to remain. In the case of spontaneous colonists in the Amazon, the point of removing them to preserve wilderness areas is moot. Once enough people are in an area to arouse official concern, the likelihood is that there is not much forest left to save.

Turning to government-planned agricultural colonies, the selection of suitable land for settlement in eastern Bolivia has been influenced to some extent by timber resources. The Bolivian government has determined that it is difficult to negotiate development loans for extractive purposes. It is less difficult to receive funding for the resettlement of highland people. Thus the latter becomes a means for securing monies for roadbuilding in areas which demonstrate promise in terms of hardwoods. It is also significant that to date colonists do not have legal rights to the timber on their own land. These rights are ceded to logging companies which pay fees to the government for timber contracts. Needless to say, settlers greatly resent this loss of immediate income and have in turn begun to negotiate with timber "pirates" who cut the colonists' hardwoods before the contractor arrives. The result has been an outbreak of violence in some colonization areas (Peacock, pers. comm. 1978).

CONCLUSIONS—The settlement process which has been outlined in the preceding pages and the social, economic, and environmental factors which impact land use patterns are found to some degree or another in most of tropical Latin America. Lately, much of the blame for the clearing of large tracts of land and their conversion to pasture has been placed on the involvement of multinational corporations such as the Jari Forestry and Ranching Company of Brazil. Still, it should be noted that for the present at least, multinational holdings represent only a small percentage of the total land area of the Amazon Basin. As corporate entites, they are subject both to government regulation and public opinion, thus offering hope for some policing activity. The greatest threat to the preservation of the Amazon wilderness is the small farmer. It is not the individual slash-and-burn horticulturalist in Bolivia, Venezuela or Brazil who is the wrong-doer. Shifting horticulture under low density populations has been shown to be an excellent means of allowing forest regeneration (Clark, 1976; Nations and Nigh, 1978). The problem is that we no longer are dealing with low density populations but with thousands of peasants in search of land and opportunity. Only when we consider the full impact of the combined efforts of the peasantry at work in the Amazon does the magnitude of the problem become apparent. It is doubtful that any government or international agency will be able to control the tide of humanity seeking its future on the Amazon frontier. A recent article in Science News (SN, Oct. 4, 1980) points out that 90% of the world population growth in the next 20 yr is expected to occur in the tropics, a fact which can only lead to greater pressure to exploit the tropical forests. When development of the Amazon is considered as a regional process crosscutting national boundaries and not as a problem inherent to any one country, the forecast for the future of this area is grim. Every nation which encompasses portions of the Amazon Basin is contributing perhaps only a few hundred hectares a day to the demise of the forest, but the cumulative effect is staggering. We can only hope that the prediction of the National Research Council's 1980 report on tropical biology is not fully realized: that the forests "will be reduced to scattered degraded remnants on steep slopes, to severely flooded delta areas and to a few parks and reserves" (Quoted in Science News: October 4, 1980).

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BENTHIC TESTACIDA (RHIZOPODA, PROTOZOA) OF LAKE WASHINGTON, BREVARD COUNTY, FLORIDA

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ABSTRACT: *Benthic Testacida from sediments of Lake Washington were studied. The Testacida were extracted using standard foraminiferologic techniques. The determined taxa were photographed using scanning electron microscopy. Twenty-one taxa were found. The majority were cosmopolitan and the most abundant were* Difflugia pyriformis *and* Centropyxis compressa. *The Testacida guild was similar to that previously studied in other American and European lakes. However, the type and size of the species were different from those found in soil and mosses.*

LAKE WASHINGTON is the third uppermost of the naturally-connected lakes of the northward flowing St. John's River. The climate of the region is humid subtropical with an average rain fall of 130 cm (Belanger and Conner, Unpubl. MS). The lake has a north-south length of approximately 6.8 km and a width of 1.7 km with an average depth of 1.0 m. The average temperature is 23.5°C in the mid-lake surface and 25.8°C in the bottom (Mason and Belanger, Unpubl. MS).

This lake is an important drinking water source for the southern part of Florida. Little is known about the protozoans that inhabit the lake. The main objective of this study is to determine the benthic Testacida of Lake Washington.

METHODOLOGY—Seven samples were studied. The samples were extracted with a petite Ponar dredge and were fixed in either 10% formaldehyde or 70% alcohol. The shells were separated from the sediments using standard foraminiferologic methods (Boltovskoy and Wright, 1975). The advantages and disadvantages of this method were previously discusssed (Lena, Unpubl. MS).

The determined species were illustrated with scanning electron microscropic micrographs. The specimens were mounted on stubs with double-faced tape and coated with gold.

SYSTEMATICS—Because the systematics of Testacida are confusing (Boltovskoy and Lena, 1974; Lena, Unpubl. MS), the original references for specific determinations were verified. The criteria and reference of another author were used when this was not possible; these are indicated by *cit. apud*. Generic determinations follow Loeblich and Tappan (1964), Chardez (1967), and Ogden and Hedley (1980).

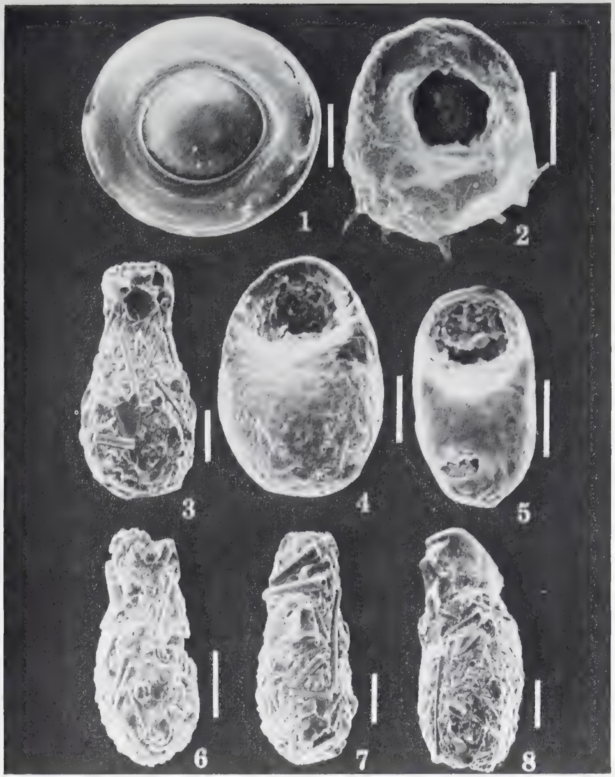
The species determined, arranged in alphabetical order, are as follows:

Arcella discoides Ehrenberg, *forma megastoma* Penard *(cit. apud.* Playfair, 1917-1918).
C. aculeata (Ehrenberg) = *Arcella aculeata* Ehrenberg, 1838, p. 133, pl. 9, fig. 6.
C. compressa (Cushman), *forma typica* = *Urnulina compressa* Cushman, 1930, p. 14, pl. 1, fig. 2.
C. compressa (Cushman), *forma brava* Boltovskoy & Lena, 1971b, p. 444, pl. 1, figs. 10-15.
C. ecornis (Ehrenberg) = *Arcella ecornis* Ehrenberg *(cit. apud.* Leidy, 1879).
C. gibba Deflandre, 1929, p. 357, figs. 118-120.
C. rioplatensis Boltovskoy & Lena, 1974, p. 17, pl. 4, figs. 14-17.
Difflugia acuminata Ehrenberg, *forma curvicaulis* Penard = *D. curvicaulis* Penard, 1902, p. 243, textfigs. 1-3.
D. acuminata Ehrenberg, *forma inflata* Penard = *D. acuminata var. inflata* Penard, 1902, p. 234, textfig. 10.
D. capreolata Penard, 1902. p. 222, textfigs. 1-6.
D. corona Wallich = *D. proteiformis* (Ehr.). Subspecies 2. *D. globulus* (Duj.). var. y. *D. corona* (Wall.), 1864, p. 241, pl. 16, figs. 19-20.
D. lithophila Penard = *D. hydrostatica* ? Zacharias, var. *lithophila* var. nov., Penard, 1902, p. 273, textfigs. 1-5.
D. mitriformis Wallich = *D. proteiformis* (Ehr.). Subspecies 1. *D. mitriformis* (Wall.), 1864, p. 240, pl. 16, figs. 7-8.
D. pyriformis Perty, *forma typica* = *D. pyriformis*, Perty, 1852, p. 187, pl. 9, fig. 9.
D. pyriformis Perty, *forma bacillifera* Penard = *D. bacillifera* Penard, 1902, p. 230, textfigs. 1-4.
D. pyriformis Perty, *forma bryophila* Penard = *D. bryophila* Penard, 1902, p. 221, textfig. 7.
D. pyriformis Perty, *forma compressa* Carter = *D. compressa* Carter, 1864, p. 22, pl. 1, figs. 5-6.
D. pyriformis Perty, *forma cyphodera* Jung, 1942, p. 277, textfig. 5.
D. urceolata Carter, 1864, p. 27, pl. 1, fig. 7.
Lesquereusia modesta Rhumbler, 1896, p. 101, pl. 4, fig. 2.
Pontigulasia compressa Rhumbler, 1896, p. 105, pl. 4, fig. 13.

RESULTS AND DISCUSSION—Twenty-one taxa of living Testacida were found. Four are new records for Florida and the U.S.A. Some species were represented by various *formae* (e.g., *Difflugia pyriformis, D. acuminata,* and *Centropyxis compressa).*

The Testacida guild of Lake Washington did not differ from a specific point of view from those previously found in other aquatic environments in Florida. However, it differed due to the scarcity of some *formae* of *Centropyxis aculeata* and species of *Arcella* (Fig. 1). For example, 4 taxa of *Arcella* and 5 forms of *C. aculeata* were found in shallow water ponds of Florida Institute of Technology gardens, while only 1 of each was found in Lake Washington. It is known that in shallow water, which are affected more by atmospheric conditions, the number of forms of *C. aculeata* is greater than in lakes and rivers (Lena and Zaidenwerg, 1975). *Arcella* is plentiful in shallow water with an abundance of aquatic plants but are not common in benthic sediments. The other species found are cosmopolitan and typical of lakes and rivers (Boltovskoy, 1956; Boltovskoy and Lena, 1966, 1971a, 1971b, 1974; Lena and Cachi, 1972; Chardez, 1965; Schonborn, 1965, 1966).

The guild of Testacida of Lake Washington differs notably from the guild of soils and mosses by the type and size of the genera. The predominant genera in soil and mosses are smaller with proteinaceous shells *(Arcella,* some *Centropyxis* and *Hyalosphenia),* siliceous shell plates *(Euglypha, Assulina,*



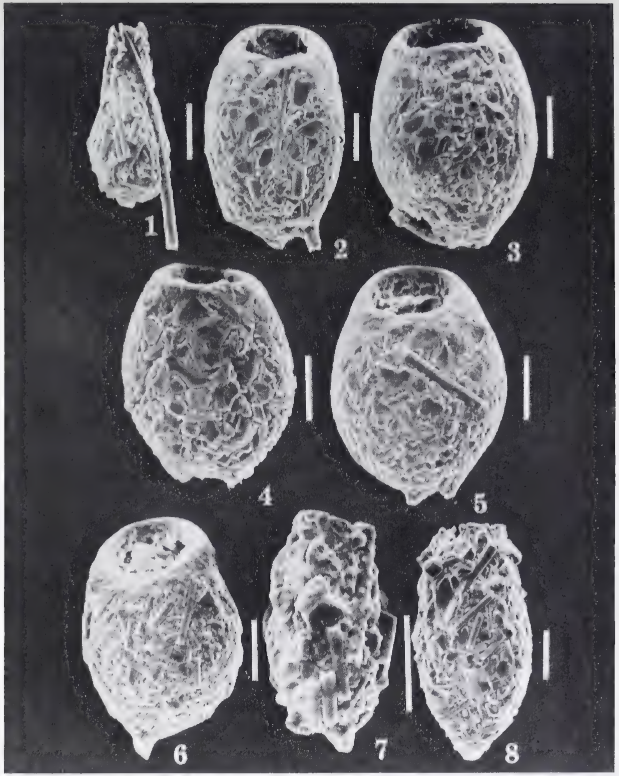
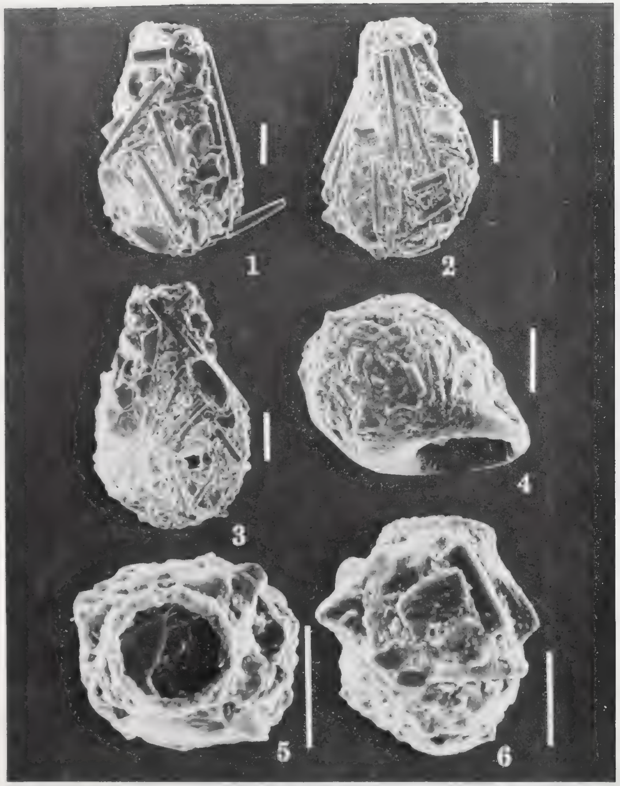


FIG. 1. Testacea Protozoa. Scale bar represents 50 μm. No. 1. *Arcella discoides* Ehrenberg, *forma megastoma* Penard. No. 2. *Centropyxis aculeata* (Ehrenberg). No. 3. *Difflugia capreolata* Penard. No. 4-5. *Centropyxis rioplatensis* Boltovskoy and Lena. No. 6-7. *Difflugia pyriformis* Perty, *forma bryophila* Penard. No. 8. *D. pyriformis* Perty, *forma cyphodera* Jung. (left).

FIG. 2. Testacea Protozoa. Scale bar represents 50 μm. No. 1. *Difflugia pyriformis* Perty, *forma bacillifera* Penard. No. 2-4. *Centropyxis compressa* Cushman, *forma brava* Boltovskoy and Lena. No. 5-6. *C. compressa* Cushman, *forma typica*. No. 7. *Difflugia acuminata* Ehrenberg, *forma inflata* Penard. No. 8. *D. acuminata* Ehrenberg, *forma curvicaulis* Penard. (right).



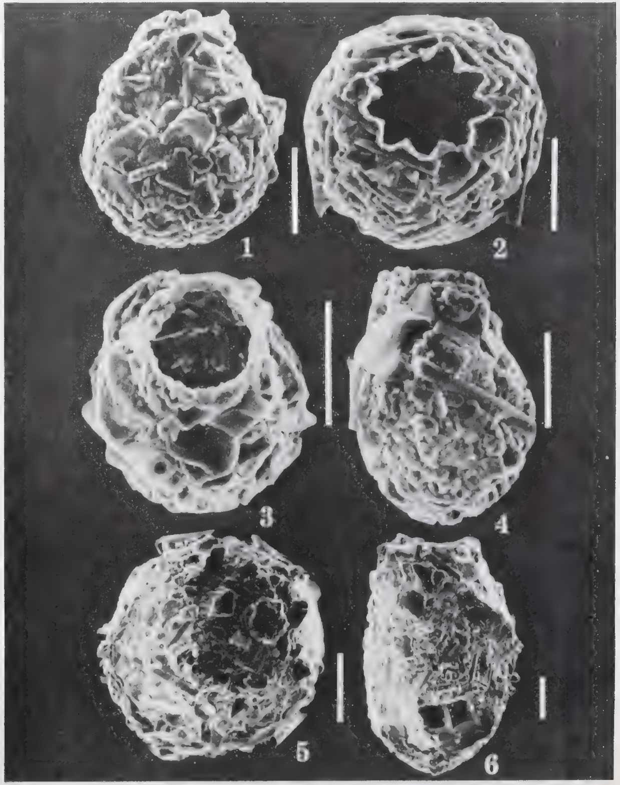


FIG. 3. Testacea Protozoa. Scale bar represents 50 μm. No. 1-3. *Difflugia pyriformis* Perty, *forma compressa* Carter. No. 4. *Centropyxis gibba* Deflandre. No. 5-6. *Lesquereusia modesta* Rhumbler. (left).

FIG. 4. Testacea Protozoa. Scale bar represents 50 μm. No. 1. *Pontigulasia compressa* Rhumbler. No. 2. *Difflugia corona* Wallich. No. 3-4. *D. lithophila* Penard. No. 5. Cyst of *D. mitriformis* Wallich. No. 6. *D. mitriformis* Wallich. (right).

and *Trinema),* and agglutinate siliceous shells *(Nebela)* (Bamforth, 1967, 1968, 1969, 1971 and Bovee, 1979).

A notable characteristic of the Testacida of Lake Washington is that the predominant element in the shells of most agglutinated species are sponge spicules (e.g., *Difflugia pyriformis, f. compressa,* Fig. 3, no. 1-3; *D. pyriformis, f. bacillifera,* Fig. 2, no. 1; *Centropyxis compressa, f. brava,* Fig. 2, no. 2-3; and *C. compressa, f. typica,* Fig. 2, no. 4-6. There is generally a slight relationship between the shell composition and the material available in the environment.

Resistant and reproductive cysts were observed in some species. In resistant cysts, the aperture was sealed by a proteinaceous membrane (e.g., *Difflugia mitriformis).* The reproductive cyst found in *Difflugia mitriformis* was a spherical structure (Fig. 4, no. 5) with agglutinated walls and larger than the shell aperature. This cyst is morphologically similar to *Psammosphaera* (agglutinate foraminifera) and it is probable that various *Psammosphaera* cited for fresh and brackish water were cyst of *D. mitriformis.*

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Biological Sciences

DISTRIBUTION OF EVERGLADES MINK

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Abstract: *Everglades mink* (Mustela vison evergladensis) *formerly were believed not to live in the true Everglades of eastern south Florida. Our data extends their known distribution to include this region.*

The Everglades Mink *(Mustela vison evergladensis)* is considered "threatened" by Brown (1978) and Smith (in press). Recent reviews (Layne, 1974; Brown, 1978; Smith, in press) suggest that this designation and concern for the status of Everglades mink are more the result of lack of biological information than knowledge that it is actually threatened. Intensive field work on this subspecies was conducted from 1 February 1978 to 31 January 1979 in true Everglades west of Miami. Work involved extensive observation periods (primarily at dawn and dusk), assessment of mink sign, retrieval of carcasses found dead on the highway, interviews with local residents, and diet analysis from scats and stomachs. Specimens were identified following Hamilton (1948) and by comparison to *M. v. evergladensis* in the University of Miami collection. Behavioral and natural history data from this study are in Smith (1980). Here we analyze the distribution of Everglades mink.

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The distribution of Everglades mink is enigmatic. It was originally described as a separate subspecies by Hamilton (1948) based on 1 specimen collected about 8 km southeast of Royal Palm Hammock, Collier County. Currently 2 problems surround the distribution of the subspecies. First, mink have an apparent disjunct distribution in south Florida, with 1 population centered around Lake Okeechobee and the other in the Big Cypress and Everglades (Layne, 1974; Brown, 1978). Layne (1974) concluded that the 2 populations are isolated and further suggested that the range of Everglades mink be regarded as being restricted to the southern population.

Second, within the southern population there has been the problem of whether mink were distributed only in the western half of the Florida peninsula or whether they extended east into the true Everglades. Most early collections and sightings of Everglades mink were from the western half of the Florida peninsula (Layne, 1974; Fig. 1). Although Bailey (1930; cited by Layne, 1974) reported a mink from Miami on the east coast, Brown (1978) ignored this specimen and confined the range of the subspecies to southwestern Florida. Similarly, Layne (1974) suggested that the range of Everglades mink be restricted to southwestern Florida "mainly west of the edge of the true Everglades."

The collected specimens and sight records of this study clearly extend the range of Everglades mink into the true Everglades of eastern south Florida (Fig. 1, Tables 1 and 2). These data suggest that the mink's range was poorly known, or that its population has expanded eastward in recent years. It is difficult to discriminate between these 2 possibilities. Interviews of longtime residents generally indicated a lack of knowledge of mink in both the eastern and western parts of its range.

While attempts were made to observe mink in all habitat types, roads and levees were followed with greatest frequency because of their accessibility. Most observations were made and specimens were collected along these artificial structures. Four animals were seen away from man-made structures. The mink population may have increased in abundance and/or expanded east with the construction of roads, levees and canals. Not only were most sightings associated with these structures, but it was here that most mink scats, tracks and runways were found. The runways were generally in sawgrass habitat within 3 m of the edge of the levee and appeared to be used

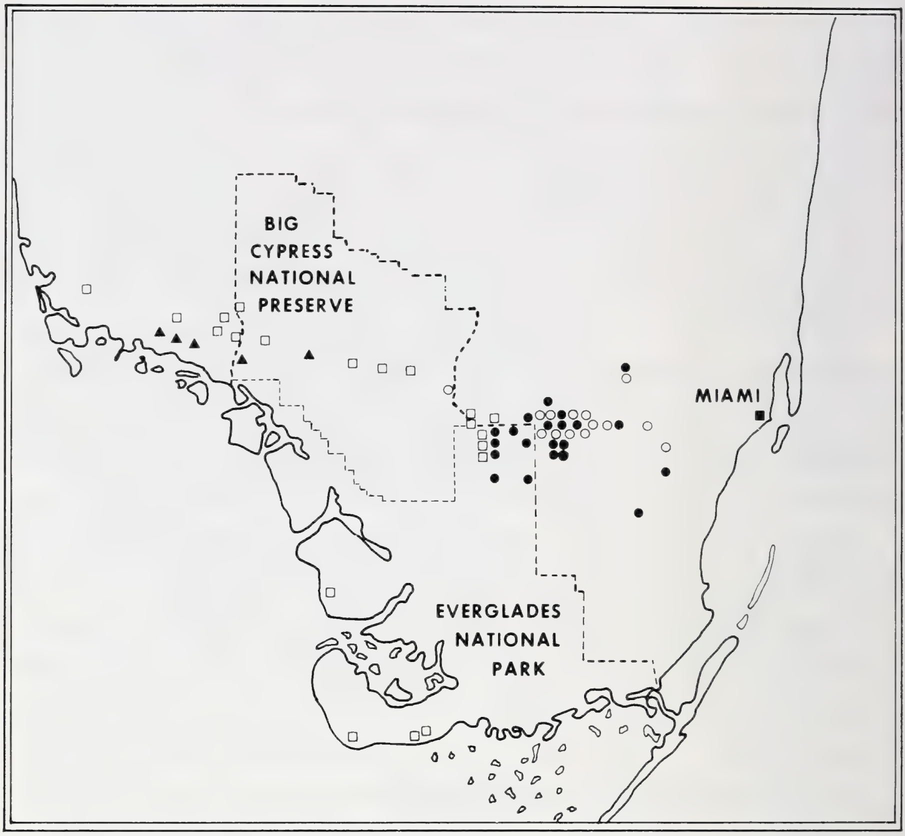

FIG. 1. Known distribution of Everglades mink in south Florida. Open circles show sites of specimens collected in the present study; closed circles show localities of recent mink sightings (Smith, 1980); and squares indicate the distribution of mink as reported by Layne (1974). The solid square is the specimen reported by Bailey (1930). Triangles indicate localities of 5 of the 6 specimens in the University of Miami mammal collection prior to this study; the sixth specimen is labeled imprecisely: "Dade County west of Miami."

frequently. Similar signs were not observed around hammocks or in the interior of the marsh.

Few direct observations of mink were made (Table 1). Most sightings were of brief duration, generally the time it took for a mink to cross a road or levee. One female was observed for an extended period of time before she was killed on the highway. This mink was observed coming to and leaving her den mainly in early morning and did not seem to be particularly sensitive to human activities. The den was in an abandoned car buried 10 m from the edge of U.S. 41, 1.5 m from the edge of a waterway dug for airboat access, and 5 m from a foot bridge connecting a parking lot with a tourist facility (Everglades Safari). She was observed taking sunfish and small rodents to the den and was lactating at death.

No relative or absolute densities of mink could be determined from our data. Sightings of mink were too few and of too diverse a nature to portray

TABLE 1. Sightings of Everglades mink. Everglades National Park (ENP) records are those of recent sightings not included in Layne (1974). L = Levee.

Locality	Date	Comments
Intersection of L67 and US 41	January 1974	ENP Record
L67, 3 km south of US41	May 1974	ENP Record
Shark Valley Tram Road just north of tower	May 1974	ENP Record
US 41, 15 km west of State Road 27	October 1974	ENP Record
Florida Turnpike, 5 km north of Snapper Creek Service Plaza	October 1974	ENP Record
Shark Valley Tram Road, north of Otter Cave	November 1974	ENP Record
Shark Valley Tram Road	October 1975	ENP Record
Shark Valley Tram Road	October 1975	ENP Record
US 41, 2.4 km east of L67	November 1975	ENP Record
US 41, west of 5 towers	February 1977	ENP Record
US 41, Everglades Safari	April 1978	Female using den (buried car)—seen over a period of a few weeks. Was seen to bring breem and small mammals to nest. Killed on highway.
US 41, 300 m west of Everglades Safari	June 1978	9:15 AM after rain. Ran across road. Couldn't be followed.
US 41, 2.4 km east of State Road 27	June 1978	6:00 PM near new construction, hence disturbance. Ran across road, could not be followed.
Eastern extension L67, 1.6 km north of US 41	July 1978	7:45 PM. Did not reappear before 9:00 PM when it became too dark to see.
L67, 11 km south of US 41	September 1978	Near pond; about 3:00 PM.
Levee west of State Road 27, 2.4 km south of Radio Tower (north of US 41)	November 1978	Four mink were seen walking along levee top at 6:00-7:00 PM.
2.4 km south of US 41 at Everglades Safari	December 1978	Animal seen at edge of small tree island.
State Road 27, south of US 41, near Glider Port	January 1979	Observed crossing road; 9:30 PM.
4.8 km south of US 41 at Everglades Safari (an abandoned Indian camp)	January 1979	Animal seen on tree island; 10:00 AM.
4.8 km south of US 41 at Everglades Safari (an abandoned Indian camp)	January 1979	Animal seen on tree island 5:30 PM
3.0 km south of US 41 at Everglades Safari	Janaury 1978	Animal seen on tree island 7:30 AM

TABLE 2. Summary of data collected from specimens of Everglades Mink. Standard mammal measurements are 1) total length, 2) length of tail, 3) hind foot and 4) ear to the notch. The first 6 specimens listed were deposited in the University of Miami collection (U of M) prior to the initiation of this study. L = Levee.

Date Collected	Locality	Sex	Weight (g)	Measurements (mm)	Comments and Disposition of Specimens
17 May 1946	"Trail Road, 6 miles west of Everglades City"	♂	?	609-171-63-22	U of M #73
20 Nov 1950	"West of Miami"	♂	?	?	No data. Not on map. U of M #404
4 July 1953	"Carnestown"	♂	?	610-192-72-27	U of M #466
28 Jan 1955	"Collier Co., 9 mi east of Ochopee on US 41"	♂	?	550-155-60-20	U of M #469
24 June 1955	"Collier Co., 4 mi west of Carnestown"	♂	?	?	No data. Complete skeleton. U of M #478
21 Oct 1956	"Collier Co., 11.4 mi east of Royal Palm Hammock on US 41"	♂	?	520-165-59-27	U of M #481
1972	US 41, 0.8 km west of Coopertown	♂	578	508-180-55-19	U of M #514, skeleton only
20 Sept 1976	Florida Turnpike at Marker 23	♂	526	535-180-63-24	U of M #513, skeleton only.
16 Dec 1977	US 41, 6.4 east of State Road 27	♂	650	534-186-54-24	U of M #511, skin and skull.
Late Feb 1978	State Road 27, 1.6 km south of Radio Tower (north of US 41)	♂	831	495-185-52-23	U of M #501, skin and skull.
Late April 1978	US 41 at Everglades Safari	♀	480	465-151-52-19	U of M #502, skin and skull.
Spring 1978	US 41, near Everglades Safari	♂	420	415-153-53-22	U of M #512, skin only.
May-June 1978	US 41, 16 km west of of State Road 27	♂	818	493-168-59-23	U of M #503, skin only.
11 June 1978	US 41, 200 m east of Frog City	♂	542	476-149-60-18	U of M #504, skin only.
1 July 1978	US 41, 1.4 km east of L67	?	?	454-171-54-22	Found gutted on road. Possibly female. U of M #505, entire body in alcohol.
18 Aug 1978	US 41, 3.5 km west of State Road 27	♂	952.5	580-189-63-24	Animal shot. U of M #506, skin and skull.
3 Oct 1978	US 41, Dade/Collier County line	♂	620	522-190-60-24	U of M #507, skin and skull.
14 Nov 1978	US 41, 5.3 km east of Everglades Safari	♀	456	462-148-51-22	U of M #508, skin and skull.

Data Collected	Locality	Sex	Weight (g)	Measurements (mm)	Comments and Disposition of Specimens
15 Nov 1978	US 41, 16 km west of State Road 27	♂	957	552-188-59-24	U of M #509, skin and skull.
25 Nov 1978	US 41, 16.3 km west of State Road 27	♂	369	440-146-57-22	Skin and skull at Archbold Biological Station, Lake Placid, FL.
2 Jan 1979	US 41, 11.4 km west of State Road 27	♂	842	542-189-60-24	U of M #510, skin only.

accurately any index of density. In addition to this problem, 12 of 14 animals sexed were males (Table 2). This strong sex bias among specimens suggests that males are more mobile than females, an observation supported by mink studies in many areas.

In spite of extensive observations in the dry season of 1978, very few mink were sighted or specimens collected at this time (Tables 1 and 2). Incidence of sightings and specimens collected increased with the onset of the wet season in 1978. Water levels remained high at the normal onset of the dry season, late 1978 to early 1979, due to flood control manipulations. At this time mink continued to be reported. It appears that mink on the study area are normally secretive yet are forced out of their normal runways and into more conspicuous settings when water levels are high. There are few above-water sites in the true Everglades for nest or den construction, and the mink may be adapted to the natural hydrology but not the artificial regime of water level that is currently practiced in the study area.

Mink were most abundant in this study at the northern edge of Everglades National Park (Fig. 1, Tables 1 and 2). This habitat is important from a management perspective because it lies directly within an area of regulated surface water discharge. Because mink are semi-aquatic, hence potentially affected by water levels, and because of their "threatened" status, their presence in the true Everglades should be considered in local management decisions.

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Biological Sciences

STATUS OF THE SILVER RICE RAT *(ORYZOMYS ARGENTATUS)*

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Abstract: *A survey by livetrapping for* Oryzomys argentatus *was conducted in the Lower Keys of Florida. Results indicate that rice rats are extirpated from the type locality and do not occur on nearby islands. Reference to the recent changes in sea level suggests that the Lower Keys population of rice rats can be no older than 3000 yr. Reasons are given for assigning* O. argentatus *to a subspecific rank. A single extant population is known from Raccoon Key.*

In Schwartz's (1952:148-149) extensive mongraph on the land mammals of southern Florida and the Upper Keys, he stated that rice rats were absent from Key Largo and the Upper Keys because of lack of suitable habitat. In the winter of 1972-1973, Spitzer (Spitzer and Lazell, 1978; Spitzer, 1978) captured 2 specimens of a previously undescribed species of rice rat, *Oryzomys argentatus*, in a freshwater cattail marsh on Cudjoe Key, Monroe County. Subsequent trapping by the authors over the next 5 yrs failed to yield another specimen.

Methods—Nine sites with potential silver rice rat habitat were located in the Lower Keys (Fig. 1), with the help of D. Kosin, J. D. Lazell, Jr., W. B. Robertson, Jr., and A. Weiner, all experienced biologists familiar with the Lower Keys. In addition, recent Mark Hurd aerial photographs were used to seek more sites. This proved unsuccessful; marsh habitat was indistinguishable from surrounding tropical forest, and only the open water of saline ponds was distinct. Six of the sites are marshes in limestone solution holes located within tropical hardwood forests. Two are roadside borrow ditches. The last is marsh vegetation that has developed in a mosquito ditch.

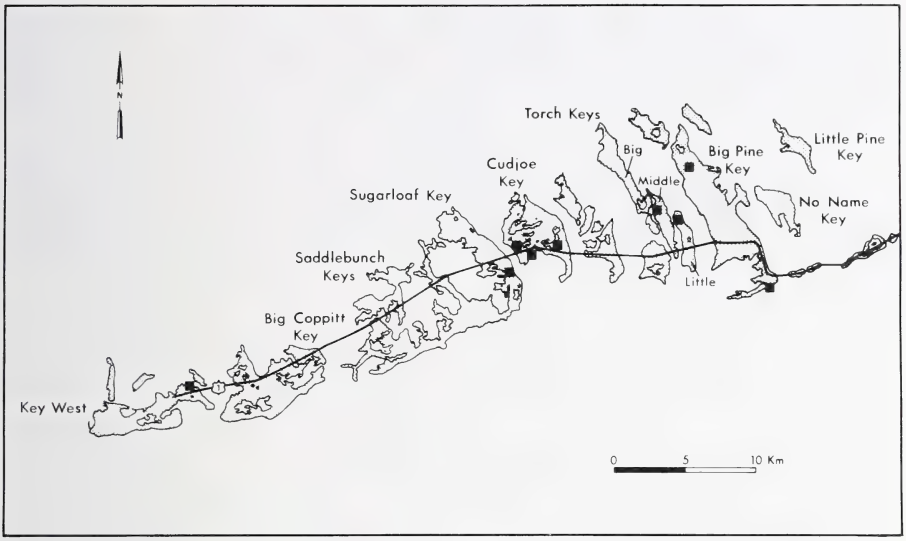

FIG. 1. Locations in the Lower Keys of the 9 marshes evaluated as potential rice rat habitat.

Descriptions of these sites follow; the designations in parentheses refer to map number and hammock number in an atlas of tropical hardwood forests of the Florida Keys (Ruttenber and Weiner, 1977).

(1) *Key West Botanical Garden on Stock Island (L 11) T 67 S, R 25 E, Sec. 27.*
(2) *Sugarloaf Key (L 10-6a) T 66 and 67 S, R 26 E, Secs. 1, 6, 31.*
(3) *Cudjoe Key, type locality (L 9-35) T 66 S, R 28 E, Sec. 29.*
(4 and 5) *Cudjoe Key (L 9) T 66 S, R 28 E, Sec. 29.*
(6) *Middle Torch Key (L 9-16d) T 66 S, R 29 E, Sec. 17 and 19.*
(7) *Little Torch Key (L 9-15) T 66 S, R 29 E, Sec. 20.*
(8) *Tree Cactus Hammock on Big Pine Key (L 8-11) T 67 S, R 29 E, Sec. 1.*
(9) *Big Pine Key Mosquito Ditches, T 66 S, R 29 E, Sec. 9.*

Sherman live traps baited with peanut butter initially were placed in pairs at intervals of 10 m. One trap was placed above the water on a mat of either cattails or sawgrass, and the other trap of the pair was placed on the moist ground adjacent to it. Trap placement was soon modified so that all traps were placed singly and over the water on matted vegetation at intervals of 5 m. This change was designed to avoid the abundant cotton rats *(Sigmodon hispidus)* at terrestrial locations and to more thoroughly sample all aquatic areas of standing cattail (*Typha* sp.) and sawgrass *(Cladium jamaicensis)*. Because each marsh was very small, all potential rice rat habitat was subjected to high-density trap placement when 5-m intervals were used. No trapping was conducted at sites 1, 5, and 8. Sampling occurred between 4 October and 8 December 1978 and on 14-16 August 1979.

Nine possible silver rice rat habitats were located (Fig. 1) and assessed subjectively as to their suitability for the silver rice rat. This evaluation was based on the presence of permanent, fresh water and dense stands of emergent vegetation, either cattails or sawgrass. Using these criteria, the pond at the Key West Botanical Garden and the 3 ponds in Tree Cactus Hammock on Big Pine Key were judged to be unsuitable for rice rats because marsh vegetation is absent. Therefore, they were not sampled. The remaining 5 areas were estimated to total approximately 2 ha in size.

RESULTS—A total of 670 trapnights, including 291 at the type locality, was accumulated, but no *O. argentatus* were taken (Table 1). A total of 30 black rats *(Rattus rattus)*, 28 cotton rats *(Sigmodon hispidus)*, 1 common yellowthroat *(Geothlypis trichas)*, and 1 Cuban tree frog *(Hyla septentrionalis)* was captured.

TABLE 1. Summary of rice rat sampling effort and rodents captured on the Lower Keys.

Sample Site	Number of Trapnights	Number and Kind of Rodents Captured
Cudjoe Key, type locality (L 9-35)	291	11 *Rattus rattus* 9 *Sigmodon hispidus*
Little Torch Key (L 9-15)	120	8 *Rattus rattus*
Middle Torch Key (L 9-16d)	72	4 *Rattus rattus* 3 *Sigmodon hispidus*
Cudjoe Key, mile marker 22-23	37	2 *Rattus rattus* 1 *Sigmodon hispidus*
Sugarloaf Key (L 10-6a)	70	5 *Rattus rattus* 2 *Sigmodon hispidus*
Big Pine Key, mosquito ditches	80	13 *Sigmodon hispidus*
Totals	670	30 *Rattus rattus* 28 *Sigmodon hispidus*

DISCUSSION—Based on the sampling reported here, we believe that *O. argentatus* has been extirpated from the type locality and is absent from nearby islands. In view of the small size of the type locality (approximately 0.3 ha including pond and borrow ditches) and the average home range size documented for *O. palustris* in Louisiana (0.33 ha for males, 0.21 ha for females, Negus et al., 1961) it is reasonable to judge that the type locality might support only 1 breeding pair of *Oryzomys*. Thus, it is possible that the taxon became extirpated when the 2 known specimens were collected in 1972-73; one was an adult female and the other was an adult, presumed to be male. Possibly competition from black rats was a problem also. The type locality itself has a tenuous existence, for the landowner plans to fill and develop the marsh.

No explanation has been proposed for the timing and way in which a form of *Oryzomys* became established in the miniscule marshes of the Lower Keys, 83 km down the archipelago from the nearest known mainland habitat, in the Everglades. According to Fairbridge (1974), the Lower Keys were mostly submerged from 6000-4700 yr before the present (BP) by a rise in sea level peaking at 4 m above the present level. After a drop to 1 m below present level, another sea level rise to 3 m above present level occurred during 4300-3400 BP. Both of these events would have submerged all the freshwater marshes reported here (as well as most of the Everglades). After another submergence of 2 m, sea level dropped to 2 m below its present level. This event would have exposed much of the bottom of Florida Bay, extending the shallow valley of the Everglades well down along the Keys. Probably the hydrologic conditions would have favored development of the marsh types familiar in the present-day Everglades, and current depths suggest that Everglades habitat would have extended as far as Ninemile Bank, Peterson Key Bank, and Lower Matecumbe Key. At the same time, most of the Keys would have been connected as larger islands, with few marine barriers to dispersal by terrestrial animals (1 km at Channel Five east of Long Key, 1.5 km at Knight Key Channel west of Vaca Key, 2 km at Moser Channel west of Pigeon Key, and 1.5 km at Bahia Honda Channel). All the Lower Keys from the Spanish Harbor Keys and Spanish Banks west to Key West would have been a single island with marshes in what now are shallow channels and basins. Therefore during the 2 m emergence, from 2000-1600 yr BP, the position of the Everglades, the configuration of the Upper Keys, and the amount of marsh habitat in the Lower Keys all probably favored dispersal of marsh animals down the archipelago. It appears that the invasion of the Lower Keys by rice rats, differentiation of *O. argentatus*, decline of its range to relictual status, and extinction of the taxon have taken place in fewer than 3000 yr.

The submergence of the Lower Keys as recently as 3400 yr BP shows that *O. argentatus* has been isolated from other forms of *Oryzomys* for a relatively short time. This interval is unusually brief for full speciation to have occurred, unless exceptionally strong selective pressures have prevailed. Further doubt about the taxonomic status of this population is cast by the diagnostic characteristics upon which the species was described (Spitzer and Lazell, 1978). Mammalian pelage color, distinctively silver-gray in *O. argentatus*, normally is controlled by genes that respond rapidly to selective pressure. In the absence of other diagnostic features, color differences are considered insufficient basis for distinguishing species. The only mensural character given in the description of *O. argentatus* is a ratio of 2 measurements, reflecting a long, narrow skull. Ratio differences commonly are considered indicative of subspecies distinctions or of incompletely separated species, such as intergrades of *Myotis californicus* with *M. leibii* (Bogan, 1974). Anderson (1965) considered 4 distinct skull characteristics to be insufficient reason to separate *Plagiodontia aeidum* into 2 species. The other 2 characters in the diagnosis of *O. argentatus* are qualitative and not illustrated in the type description. It appears likely that *O. argentatus* should be given subspecific rank, but this point will remain unresolved until a larger sample is available for examination.

Because we intensively sampled all known marshes at times of high and low water levels, we think additional sampling at these sites is likely to be fruitless. Subsequent to completion of our study, we learned that 9 *O. argentatus* were taken in grassy areas and in rocky areas near water on Raccoon Key during June 1976. We have examined the only specimen saved (No. 02363, Bowling Green State University) and confirmed its identity.

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NEW SPECIES OF PRIMITIVE THREE-TOED BROWSING HORSE FROM THE MIOCENE PHOSPHATE MINING DISTRICT OF CENTRAL FLORIDA

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ABSTRACT: *Dental and postcranial remains of the primitive three-toed browsing horse* HYPOHIPPUS CHICO, *new species, are described from the Bone Valley phosphate mining district of central Florida. This is the first report of this genus from eastern North America.* HYPOHIPPUS CHICO, *the smallest known species of* HYPOHIPPUS, *is clearly referable to this genus based on several diagnostic dental characters. The Florida* HYPOHIPPUS CHICO *supports the presence of medial Miocene (i.e., pre-Hemphillian) units within the Bone Valley Formation.*

DURING the present century an abundant suite of fossil vertebrates has been recovered from the open-pit phosphate mining operations of Polk and adjacent Hillsborough counties in central Florida. The biochronology of the best-known land mammals collected from these sediments, particularly the upper part of the Bone Valley Formation, indicate a Hemphillian (latest Miocene to earliest Pliocene) age (e.g., Tedford et al., in press; MacFadden and Webb, in press). The faunas from the upper part of the Bone Valley Formation further subdivide into early and late Hemphillian biochrons with a regional erosional hiatus at about 6 myBP that probably represents the global drop in sea level of the Messinian Salinity Crisis (e.g., Webb et al., 1978). Sediments and faunas of pre-Hemphillian age in the Bone Valley district are very poorly known and have not yet been adequately described in the literature.

Within this central Florida Bone Valley sequence, mammals have been collected that are known to have become extinct in the midcontinent of North America by Hemphillian time. Thus, it has been hypothesized that the Florida Gulf Coastal region for some reason, possibly as a result of climatic differences, provided a refugium for "relictual" species that persisted in the latter region into the Hemphillian time. Recent work, mostly unpublished at present, marshalls data indicating that, in addition to the dual succession of Hemphillian faunas and sediments in the Bone Valley region, there are significantly older vertebrates collected from these mines (see preliminary report in MacFadden and Webb, in press).

I describe a new species of the primitive three-toed browsing horse *Hypohippus* from the Bone Valley Formation of the central Florida phosphate mining district and discuss the biochronological implications of this occurrence.

It is appropriate to briefly discuss the provenance of vertebrate fossils from the Bone Valley Formation. These specimens are most frequently unearthed during dragline operations in the open-pit mines and then are dumped into adjacent wells. The phosphatic matrix is then subjected to high-pressure streams of water to produce a slurry for transport to the refining plant. As a result of this process, the residual fossils found in these wells are oftentimes broken or consist of isolated teeth. In addition, the exact stratigraphic provenance and faunal association of these fossils cannot be readily determined. Less frequently, fossils are collected *in situ* with relevant stratigraphic and faunal association. These latter important sites provide the frame of reference for the more frequent isolated finds. In short, because of the nature of the phosphate mining operations and consequent methods of fossil collecting, detailed biostratigraphic studies in this region are discouraging at best. Biochronological studies have to rely on homotaxial comparisons with the few *in situ* localities as well as correlation to the extensive stratigraphically controlled localities in the midcontinent.

In the text the abbreviation UF is used for specimens housed in the Vertebrate Paleontology Collection, Florida State Museum, University of Florida, Gainesville. All measurements are in millimeters. The dental nomenclature used here follows Stirton (1940, 1941), Skinner and Taylor (1967), and Skinner and MacFadden (1977).

SYSTEMATIC PALEONTOLOGY
CLASS MAMMALIA LINNAEUS 1758
ORDER PERISSODACTYLA Owen 1848
Family Equidae Gray 1821
Genus *Hypohippus* Leidy 1858
Hypohippus chico new species
Figures 1-3; 1 Table

Type Specimen and Locality — UF 18529, maxillary fragment with right P^3-P^4, from Noralyn Mine, collected by Mr. William MacDonald in 1970 from about 8 km south of IMC office, Bone Valley Formation; medial Miocene (either Barstovian or Clarendonian) of Polk County, Florida.

Etymology—*chico*, spanish for little, little one.

Geographic and Stratigraphic Distribution—Restriced to Noralyn (type locality) and Brewster (American Cyanamid Hainesworth) mines (Fig. 1), Bone Valley Formation; medial Miocene (either Barstovian or Clarendonian) of Polk County, central Florida phosphate mining district.

Referred Material, Collectors and Localities—UF 18529, holotype, see above; UF 32034 right P^2, provenience unknown, cast of B307, specimen in private collection of Bill and Lelia Brayfield, El Jobean, Florida. UF 32025, left P^4, and UF 32026 left lower molar, both collected from Brewster Mine in 1980, casts of specimens in private collection of Joe Larned, Bradley, Florida; UF 24006, second medial (III) phalanx collected by Frank Garcia in 1978 from NE corner of Noralyn Mine.

DIAGNOSIS—Medium-sized brachyodont browsing horse. Teeth lack cement and crochet. Differs from *Anchitherium* because of the absence of ribs between styles in the upper cheek teeth. Differs from the other species of *Hypohippus* because of its significantly smaller size. Differs from *Megahip-*

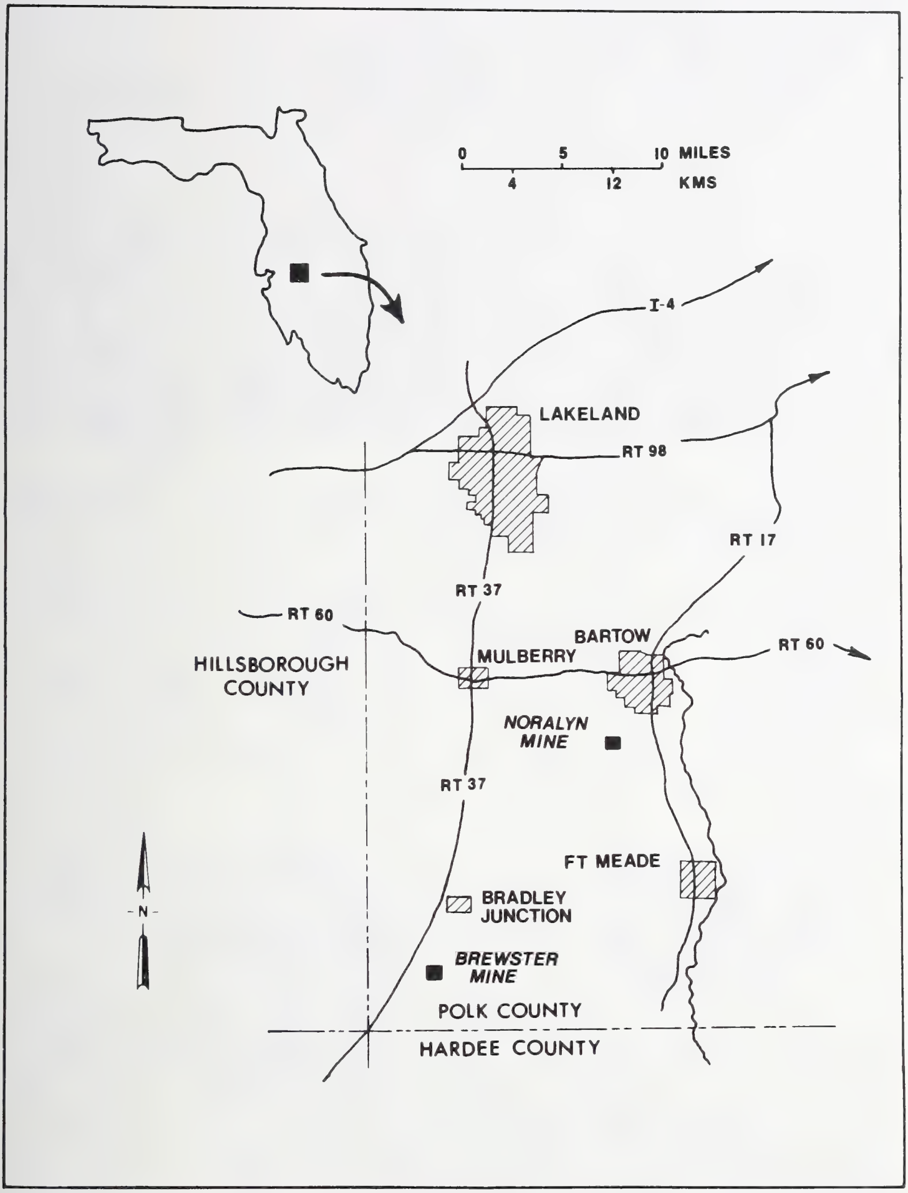

FIG. 1. Location of the phosphate mining district of Polk and Hillsborough counties in central Florida. The specimens of *Hypohippus chico*, new species, discussed in this report were collected from the Noralyn and Brewster mines (italics).

pus because of its significantly smaller size and lack of a continuous cingulum on the cheek teeth.

Description—This is the smallest species of *Hypohippus* (Table 1). It approximates the size of some of the larger species of *Anchitherium* (e.g., *A. clarenci* from Thomas Farm, Florida, and *A. aurelianense* from the Old World). *Hypohippus chico* is brachyodont relative to other species of this genus (Fig. 2). Very little expansion of crown height is seen in the more advanced grazing horses. In the P^2 there is an anteroexternal extension of the ectoloph, the parastyle, anterior to the pseudoparastyle that gives this tooth a rhomboidal rather than rectangular outline. The parastyle is very prominent. The mesostyle and metastyle are less well developed. There is a small cusp in the position of the internal cingulum between the protocone and the hypocone. All of the available upper cheek teeth demonstrate the following characters: There is a W-shaped ectoloph. The ribs on the styles are very poorly developed or absent. The hypostyle is well developed. The cingulum is developed, although sometimes discontinuously, on the anterior, anterointernal, and posterior portions of the teeth but is faint or absent on posterointernal portion of the teeth internal to the hypocone. The crochet is absent and there is no cement.

Table 1. Dental measurements (mm) for *Hypohippus chico* from the Bone Valley Formation of the phosphate mining district of central Florida.

Specimen	AP length	T width	Crown[1] height
UF 18529 (holotype)			
R P^3	19.9	21.1	7.2
R P^4	19.5	23.7	9.2
UF 32024			
R P^2	22.3	20.6	11[@]
UF 32025			
L P^4	22.8	25.1	16.7
UF 32026			
L $P_?$	18.4	11.7	12.0[2]

[1] Maximum measurement taken from base of enamel (at the contact with the root) to the occlusal surface of the ectoloph.

[2] Maximum measurement from base of enamel to occlusal surface of metaconid-metastylid.

[@] Measurement approximate.

The lower dentition of *Hypohippus chico* is known only from a single lower cheek tooth (it could be P_3-M_2). There is no cement. The cingulum is absent. The protoconid and hypoconid have rounded external borders. The ectoflexid is very deep. The metaconids and metastylids are neither widely separated nor expanded as in advanced horses. The linguaflexid on the internal enamel border that separates these two structures is very shallow. The entoconid is larger than the hypoconulid.

A second medial (III) phalanx, UF 24006, from the same mine as the holotype is probably referable to *Hypohippus chico* (Fig. 3). This element

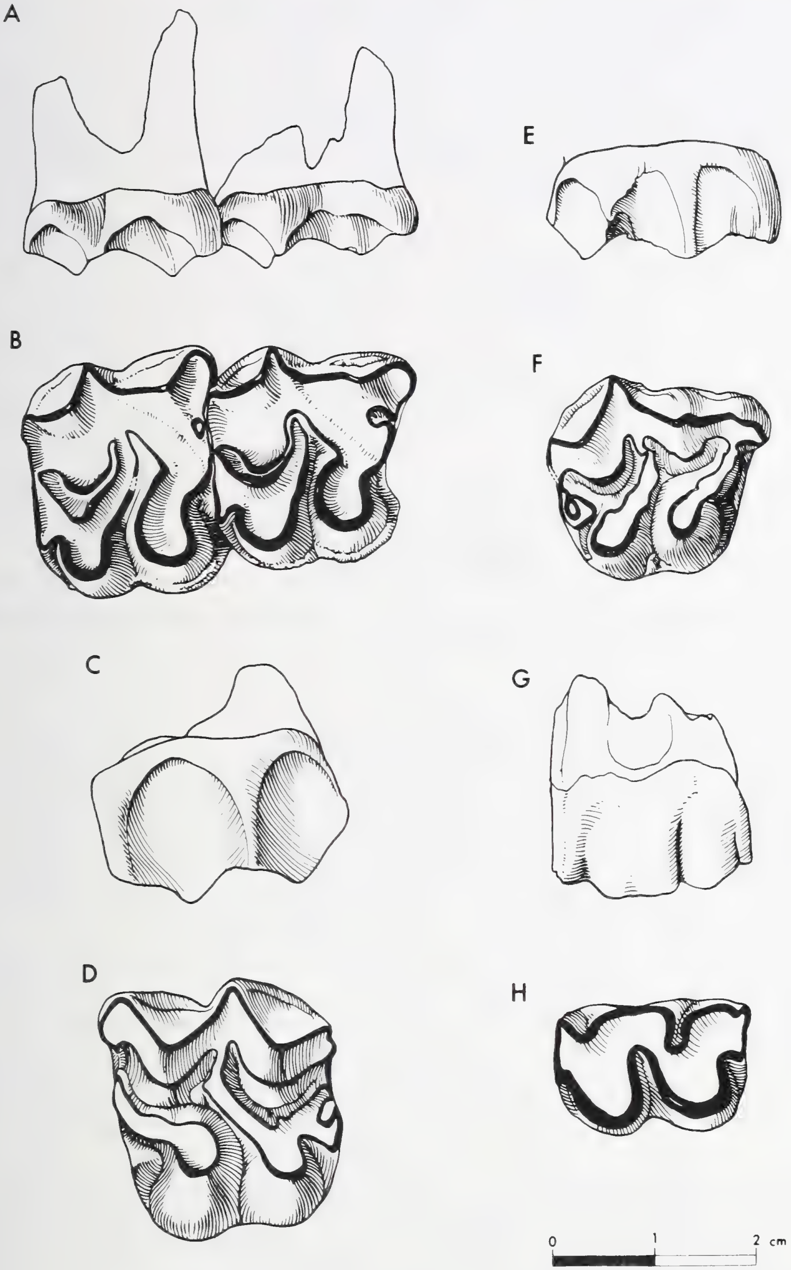

Fig. 2. Upper and lower cheek teeth of *Hypohippus chico*, new species, from the Bone Valley Formation of central Florida. UF 18529 (holotype), right P^3-P^4, labial (A) and occlusal (B) views. UF 32025, left P^4, labial (C) and occlusal (D) views. UF 32024, right P^2, labial (E) and occlusal (F) views. UF 32026, left lower cheek tooth, lingual view showing crown height at metaconid-metastylid (G) and occlusal view (H).

is dorsoventrally flattened. It is primitive for tridactyl equids in the lack of anteroposterior elongation (greatest length = 34.2 mm) relative to the transverse width (at proximal articular surface = 32.2 mm) as noted by Sondaar (1968) and Hussain (1975). Without direct association with dentitions, it is always possible that this specimen is not *Hypohippus*, however, this is unlikely; the other taxa of Bone Valley horses demonstrate more derived proportions for this podial element.

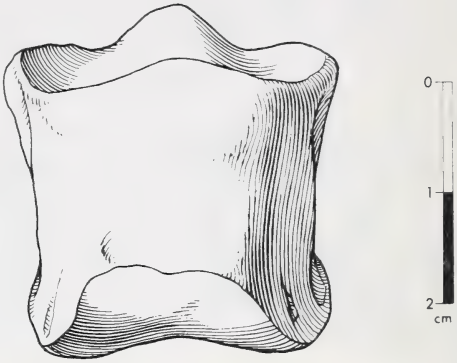

Fig. 3. Dorsal view of second medial (III) phalanx of *Hypohippus chico*, new species, from the Bone Valley Formation of central Florida.

Discussion—The anchitheriine, or three-toed browsing horses as presently recognized in North America, consist of the genera *Anchitherium*, *Hypohippus*, and *Megahippus*. Despite the fact that horses are generally abundant and well studied in the North American late Tertiary sequence, these browsing horses are relatively rare and poorly known. Except for the revisions by Osborn (1918) and Stirton (1940), discussion of these horses have mostly resulted from faunal studies (e.g., Webb, 1969).

Stirton (1940) listed the following species of *Hypohippus: H. equinus* (Scott) 1893, *H. osborni* Gidley 1907, *H. affinis* Leidy 1858, and *H. nevadensis* Merriam 1913. The occurrences of these species indicates a medial Miocene (Barstovian to Clarendonian) range for this genus. During the present study, the Bone Valley specimens of *Hypohippus* were compared to these four species as represented in the large collection at the American Museum of Natural History. The Florida sample exhibits diagnostic characters of *Hypohippus*, i. e., well developed styles, ribs absent on ectoloph, and discontinuous cingula (see Stirton, 1940). However, the Florida *Hypohippus* is significantly smaller than the four species recognized by Stirton (1940). In addition, from the illustration in Osborn (1918, p. 65), Leidy's (1873) *Anchitherium* (?) *australe* might be referable to *Hypohippus*. *Anchitherium* (?) *australe* is only known from a broken P^2 collected from a well dug at a depth of about 10 m at Independence in Washington County of the Texas Gulf Coastal Plain. From the original description and illustration, "*H.*" *australe* is small and possibly is similar to *H. chico*. Leidy did not assign a museum number to this specimen (housed in the Academy of Natural Sciences in Philadelphia), and it has since been lost. Without additional topotypic or referred material and the virtually undiagnostic nature of the lost holotype, Leidy's *Anchitherium* (?) *australe* is considered here to be a *nomen dubium*. Therefore, even though the Florida sample of *Hypohippus* possibly represents the same taxon as *A.* (?) *australe*, the latter "species" is of no taxonomic utility.

Prior to this report, *Hypohippus* had not been known from the Bone Valley Formation. There are several explanations for this occurrence, two of which will be discussed here. Based on studies of other Miocene land mammals in Florida, it has been suggested that this region was a climatic refugium for relictual taxa. This occurrence of *Hypohippus* could be interpreted as further evidence of a relictual species in the Florida Gulf Coastal Savanna Corridor (*sensu* Webb, 1974).

The second plausible explanation for the presence of these land mammals is that they are not relicts but that they originated in pre-Hemphillian units low in the Bone Valley Formation. Until recently, either of these two explanations would have been equally plausible. However, based on recent careful collecting of *in situ* fossil occurrences in the Bone Valley Formation, there seem to be localized older units of probable Barstovian or Clarendonian (medial Miocene) age in this sequence. With reference to the occurrence of *Hypohippus chico*, I favor the interpretation that this three-toed browsing horse, rather than being a relict, was collected from units low in the Bone Valley Formation. Confirmation of this hypothesis can only come from future collections of *in situ* faunules containing *Hypohippus chico* in association with other medial Miocene land mammals.

Besides *Hypohippus*, the other equid taxa from the Bone Valley Formation include *Merychippus*, *Dinohippus*, *Pseudhipparion*, *Calippus*, *Nannippus*, *Neohipparion*, *Astrohippus*, and possibly *Cormohipparion* (although the nature of the material makes it difficult to identify the presence of the latter genus). In summary, the present report adds to the known diversity of horses from the Bone Valley Formation, it represents the first occurrence of primitive three-toed browsing horses from this region, and supports the hypothesis of medial Miocene units within the central Florida phosphate mining district.

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Physical Sciences

UPWELLING IN ATLANTIC SHELF WATERS OF SOUTH FLORIDA

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ABSTRACT: *Subsurface temperature data from 8 stations were obtained for 6 wk during the summer of 1978 to describe seasonal upwelling along the Atlantic coast of Florida just south of Cape Canaveral. Available data show one major upwelling event occurring during the first 3 wk of August. Bottom temperatures suggest that cool water advances rapidly toward the coast, and nearshore water cools by as much as 7°C within 2 wk. A strong thermocline is maintained throughout the upwelling event. The available data base is inadequate to resolve the primary forcing mechanisms, but related studies suggest that upwelling may occur in response to the Florida Current as much as to the coastal wind field.*

A SUBSTANTIAL BODY of literature has accumulated within the past several years because of an increased interest in the causes and effects of the upwelling of ocean waters. In a geographical sense, attention has focused upon a relatively few coastal areas off the west coasts of North America, South America and Africa, where upwelling is either quasi-persistent or annually recurring.

In many cases, upwelling can be explained in terms of classical Ekman dynamics, as a response to persistent or seasonally variable synoptic scale wind systems. West coast locations in both hemispheres commonly exhibit wind-driven upwelling, but even midocean areas may show upwelling under the trade winds in a band along the equator, where a divergence in the surface layer of the ocean occurs with the change in sign of the Coriolis force.

Studies carried out in a variety of coastal settings, however, suggest that any of several alternate mechanisms may play a significant role at a given place and time. Houghton (1976) has described upwelling during the summer months off the coast of Ghana, where it is postulated that the coastal wind field is not a primary driving force. Nearby, in the Gulf of Guinea, seasonal upwelling has been interpreted in terms of an equatorially-trapped Kelvin wave generated by winds well out in the Atlantic which reflects at the coast and moves north as a Rossby wave (Adamec and O'Brien, 1978).

Hsueh and O'Brien (1971) have demonstrated that even in the absence of windstress forcing upwelling may occur as a dynamic readjustment in a coastal current which is frictionally retarded in near-bottom layers by the continental shelf. This process is used to explain upwelling off the coasts of Oregon and Peru, and in shelf waters off the Gulf coast of Florida. Recently, Janowitz and Pietrafesa (1980) have described upwelling in a boundary current in response to topographic features of the continental shelf. Recent studies of alternate forcing mechanisms have stimulated investigations in more diverse coastal and open ocean settings, as well as provided explanations of the upwelling patterns when they are recorded.

Although coastal upwelling is more often associated with the west coasts of continents, recurring upwelling patterns have been noted in east coast settings. An example of this is the annually recurring upwelling which appears during the summer along Florida's Atlantic coast. This was first documented by Green (1944), who suggested that anomalously low water temperatures occurred during June, July and August along an approximately 600 km section of coastline centered at about latitude 29 °N. This study was followed by a more complete investigation by Taylor and Stewart (1958), which described upwelling somewhat more precisely in space and time (Fig. 1), and which suggested that the process occurred in response to seasonal variations in coastal winds. Climatological data from 8 locations between Charleston and Key West were compared with multiannual mean monthly surf temperatures. Water temperatures between approximately 27° and 31 °N decreased during midsummer months, and this was interpreted as a response to longshore variations in the sign of the cross-shelf component of the surface wind.

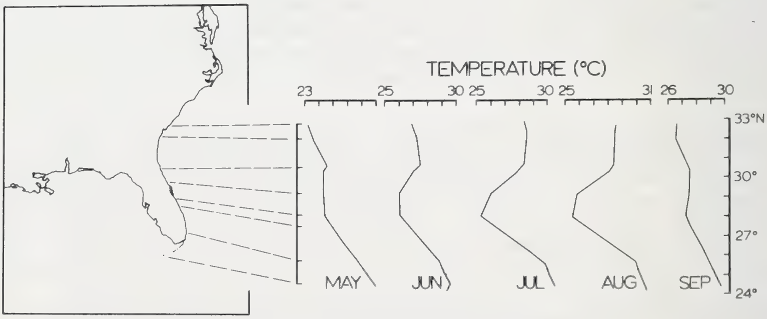

FIG. 1. Multiannual monthly average surf temperatures (in °C) for summer months between 24° and 33°N. After Taylor and Stewart (1958).

More recently, Lemming (1979) used hydrographic and meteorological data from Atlantic shelf waters near Cape Canaveral to describe summer upwelling. Coastal windstress was found to be coherent with bottom temperatures over the inner shelf at subtidal frequencies. Both Ekman transport and the Florida Current were felt to play a role in driving the upwelling.

Previous work conducted locally in Florida shelf waters defines in a general way the nature and characteristics of upwelling in this region, and suggests that causes may go beyond local wind forcing. In addition to an Ekman transport of nearsurface water away from the coast, upwelling may be related to the presence of the Florida Current just beyond the shelf. A study conducted in the summer of 1978 was designed to extend previous work in Florida shelf waters in 3 ways: First, measurements were made across the shelf to relate the movement of water from near-bottom or intermediate depths further offshore to the anomalously low surf temperatures recorded at the coast. Second, data were collected at weekly intervals to document better the temporal variability in cross-shelf temperature structure. Third, the study was conducted at approximately the southern extreme of the section of the coastline along which upwelling has been reported, thus improving spatial resolution.

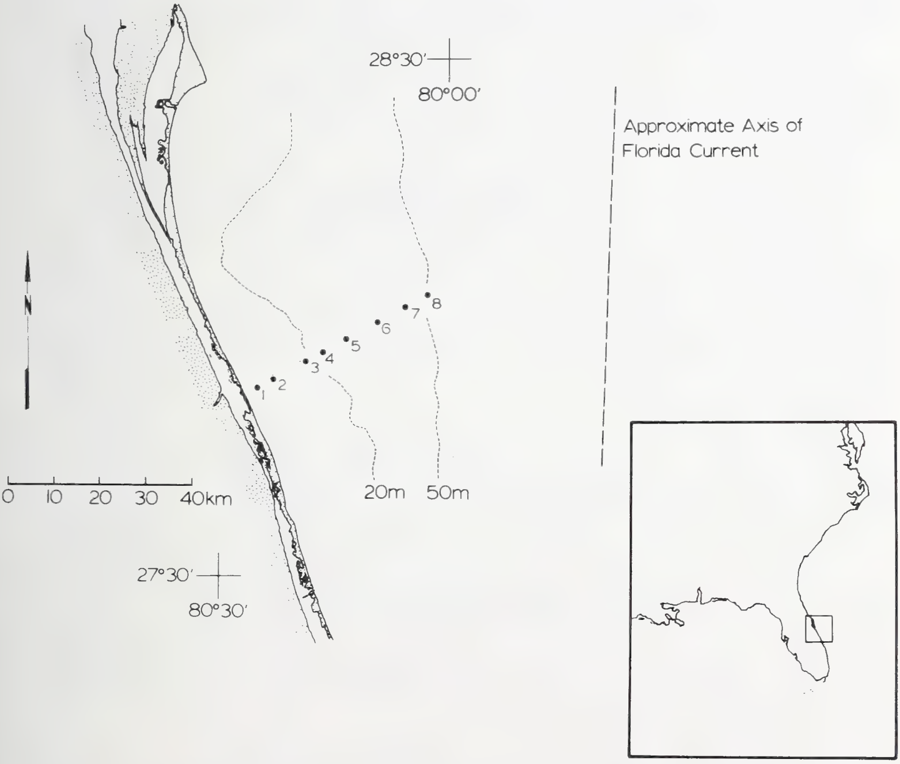

FIG. 2. Location of hydrographic sampling stations 1-8 on the Atlantic shelf of Florida.

Observations—The temperature data used to document and describe upwelling were obtained as top-to-bottom profiles with a Plessey Model 9060 Salinity, Temperature, Depth Profiling System (STD), or with a Beckman Model RS5-3 Field Salinometer in the shallow water over the inner shelf. Temperature profiles were digitized at intervals of 1-2.5 m, depending upon the vertical temperature gradient at the time and place of measurement. Temperature profiles were calibrated at surface and bottom levels with reversing thermometers, and corrected temperatures are believed to be accurate to within 0.1 °C.

Seven hydrographic stations were visited weekly from 19 July to 30 August 1978; an eighth station, closer to the coast, was added on 2 August. Water depth varied from 15 m at Station 1 to 55 m at Station 8 (Fig. 2). The average cross-shelf slope in the vicinity of the study area was approximately 1 m/km. Bathymetric charts indicate a slight divergence to the north in the mid shelf isobaths. Ship drift recorded while on station at the offshore end of the transect suggested that the Florida Current was not having a direct effect on shelf waters at that location.

Results—Cross-shelf temperature profiles show the result of coastal upwelling, due to the resulting strong vertical temperature gradients during summer months. Figure 3 shows the cross section obtained on 19 July. Shelf waters vary from very nearly isothermal at the shoreward end of the transect to highly stratified at the outer station. Warmest water is a shallow lens of just over 28 °C, centered approximately 30 km offshore. At near-bottom levels, isotherms show a distinct tendency to intersect the bottom rather than to parallel it.

The temperature cross section constructed from data collected the following week (Fig. 4) indicates temperatures generally 2-3 °C warmer over the inner shelf. Over the middle and outer shelf, isotherms in the lowest 10 m tend to parallel the bottom, and the strongest horizontal temperature gradients along the bottom are found between 10 and 20 km from the coast. The surface temperature gradient is directed seaward, though inner shelf temperatures are only about 1 °C warmer than those recorded over the outer part of the transect.

Figure 5 is constructed from temperatures recorded on 2 August and shows a significantly different pattern from that of the preceding week. The thermocline is well-established at about the 10 m level and extends across the entire shelf. Also, the horizontal temperature gradient at the surface is directed shoreward. Surface temperatures at the innermost station are 2.5 °C cooler than at the offshore end of the transect, and nearly 3 °C cooler than the preceding week. A small area of water just below 17 °C appears in the cross section just above the bottom approximately 15 km from the coast. The data suggest that an upwelling pattern has become established during the week of 26 July to 2 August.

The strong stratification persists through the following week (Fig. 6), and the thermocline appears to have risen slightly in the water column. On

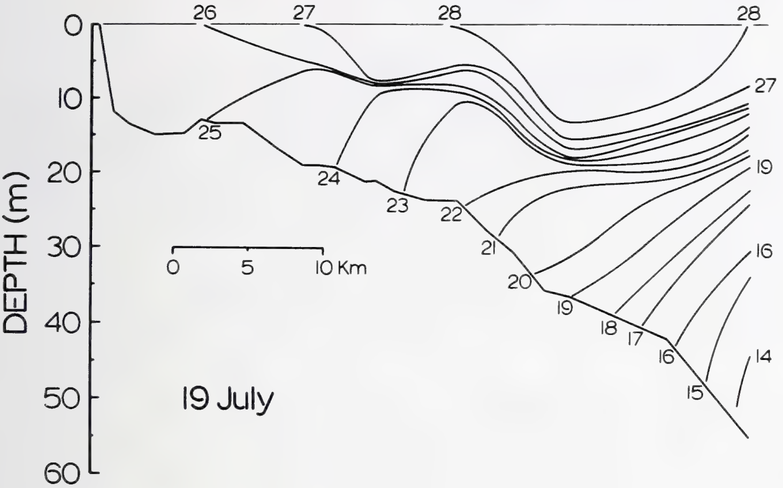

FIG. 3. Temperature cross section (°C) from 19 July 1978.

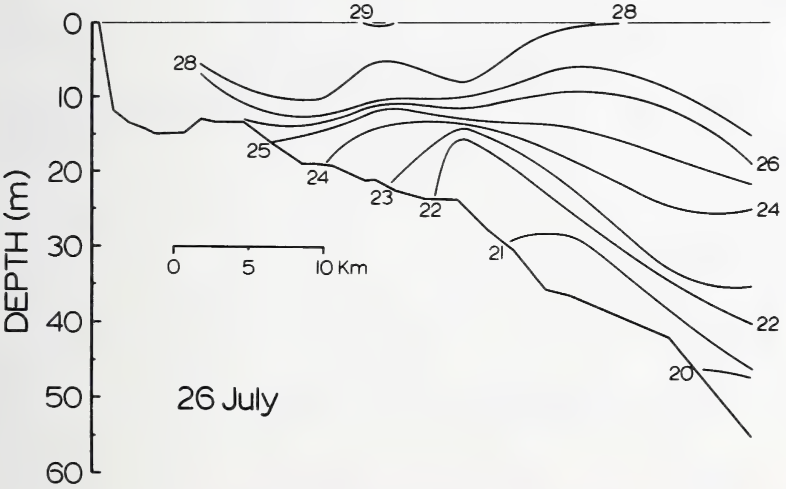

FIG. 4. Temperature cross section (°C) from 26 July 1978.

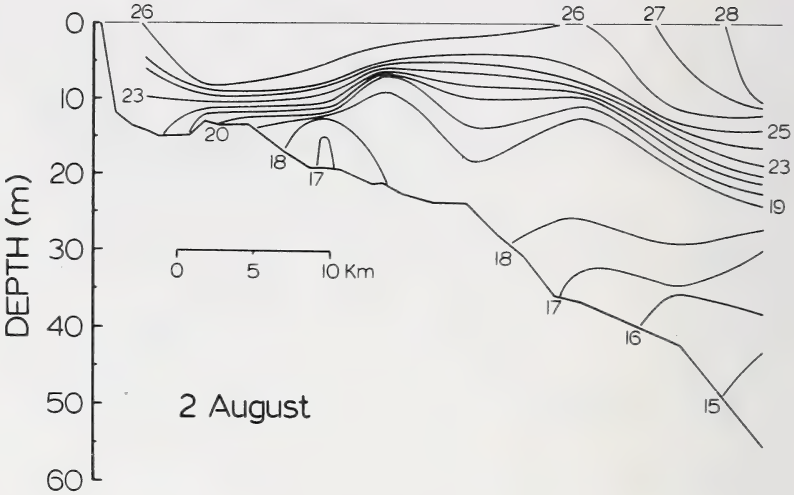

Fig. 5. Temperature cross section (°C) from 2 August 1978.

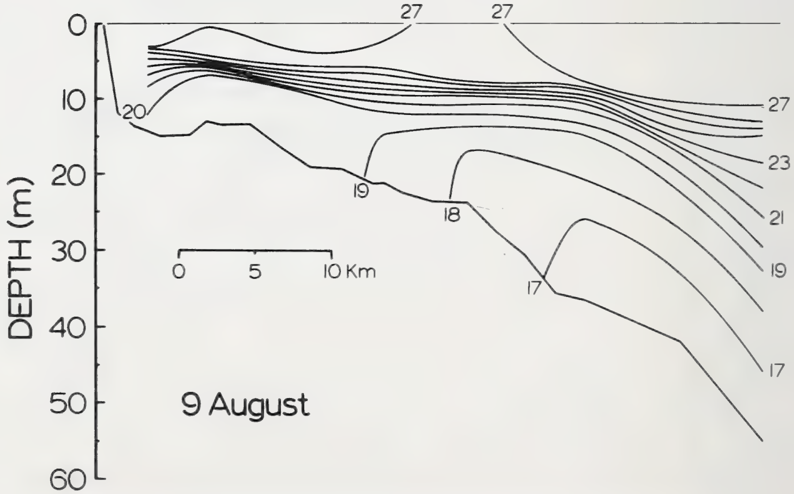

Fig. 6. Temperature cross section (°C) from 9 August 1978.

the other hand, the shoreward temperature gradient in the surface layer is no longer clearly defined. Although the 20° isotherm can be traced across the entire transect, the 19°, 18° and 17° isotherms intersect the bottom over the middle shelf.

Figure 7 indicates that a continuation of the upwelling pattern exists during 9-16 August, with one important exception. The 18° isotherm has retreated over 15 km seaward in the near-bottom layers, and warming just above the bottom over the middle shelf is nearly 2°C. Still, near-bottom cooling of as much as 2.5°C is recorded at the outer end of the transect.

The temperature cross section for 23 August (Fig. 8) suggests a slight weakening of the thermocline, warming of as much as 4°C in the near-bottom layers over the outer part of the transect, and the establishment of an offshore-directed temperature gradient in the surface layer. The general trend appears to be one of warming over the preceding week and a lessening of the upwelling pattern.

The final temperature cross section in the series is shown in Figure 9. Warming has continued through the near-bottom layers, with temperatures about 2-3°C higher. For the first time since 26 July, the 29° isotherm appears in the cross section—at the surface over the inner shelf, and again through the upper 15 m at the outer station. The thermocline has continued to weaken slightly and in this cross section slopes downward in a seaward direction beyond about 30 km from the coast.

It is apparent from the above that the greatest temporal variability in temperature recorded during this study is in the near-bottom layers. Thus, to investigate the warming and cooling of near-bottom water along the transect during the 7 cruises, the bottom calibration temperatures were entered on a time-distance plot (Fig. 10) and contoured to show the cross-shelf movement of isotherms during this 6-wk period. The pattern suggests relatively stable conditions during the first week of this study, followed by a rapid cooling during the week of 26 July to 2 August. For example, bottom temperatures at Station 3, 16 km from the coast, indicate a net cooling of just under 7.2°C. During this time, the 20° isotherm advances approximately 33 km shoreward, moving at an average speed of 0.2 km/h, or 5.5 cm/s. With cool water extending all the way to the coast in early August, cross-shelf temperature gradients are relatively minor in the near-bottom layers. The final 2 wk of the study indicate a slow warming across the shelf, as isotherms retreat seaward.

Although the onset of the upwelling pattern is defined better than the end, the period of 26 July-2 August is the start of an upwelling event, and the week of 16-23 August represents the end, insofar as it existed along this part of the coast. To investigate and describe these 2 conditions more quantitatively, cross sections were constructed and contoured using the temperature differences found at a given level at each station. Figure 11 shows the temperature differences for the time period over which cool water was moving shoreward. Negative values indicate a net cooling. Strongest cooling of

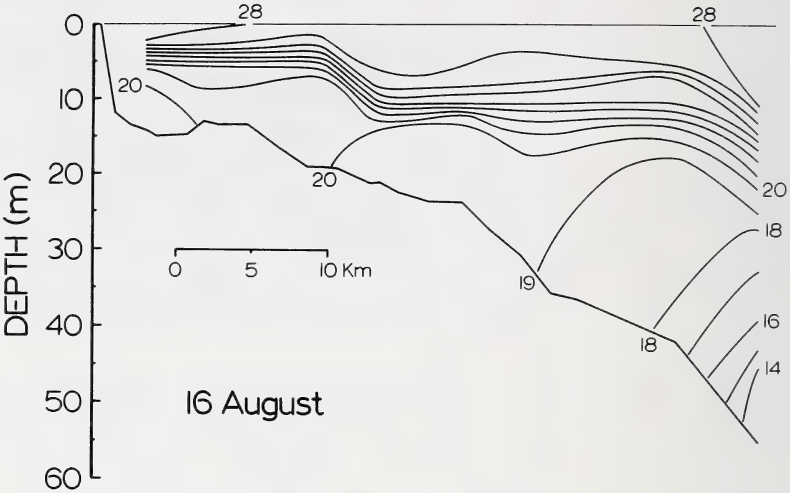

Fig. 7. Temperature cross section (°C) from 16 August 1978.

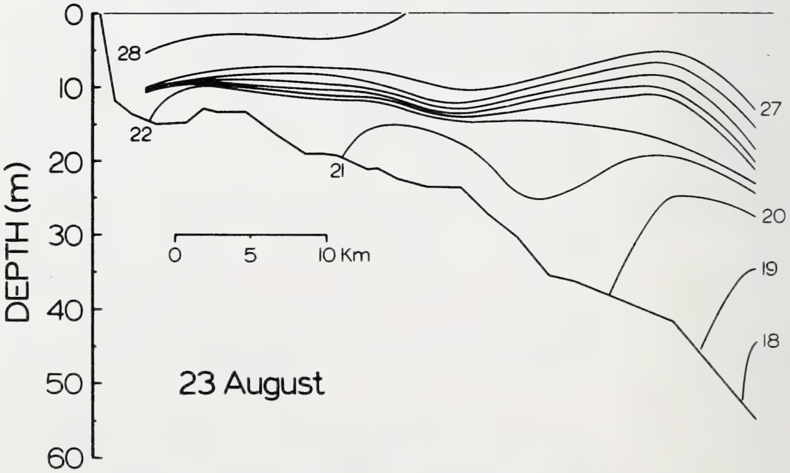

Fig. 8. Temperature cross section (°C) from 23 August 1978.

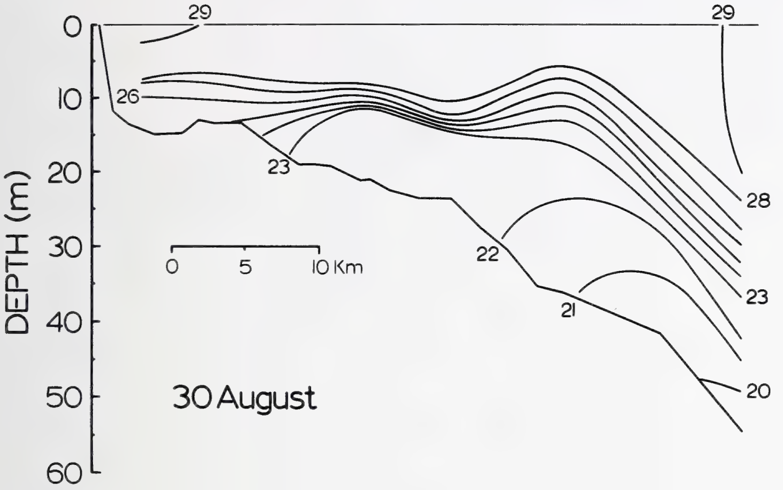

FIG. 9. Temperature cross section (°C) from 30 August 1978.

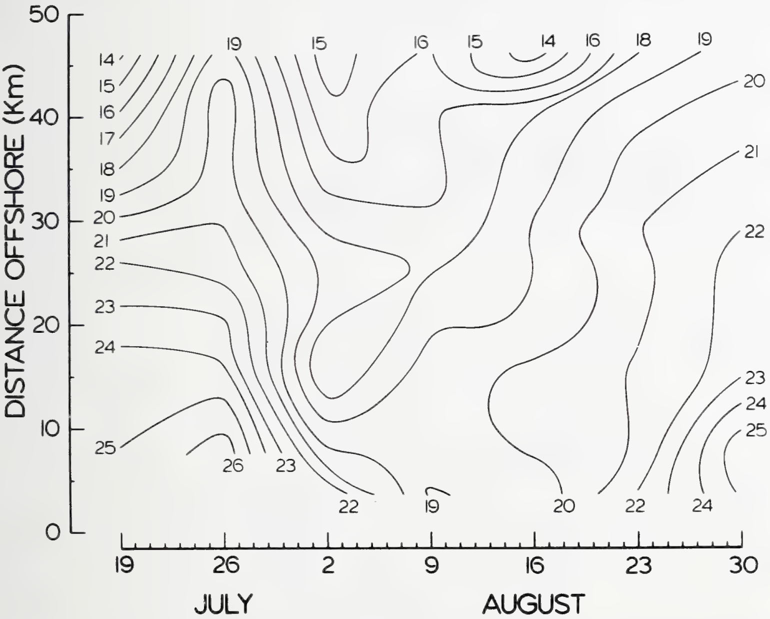

FIG. 10. Time-distance plot of bottom temperatures (°C) recorded between 19 July and 30 August 1978 at Stations 1-8.

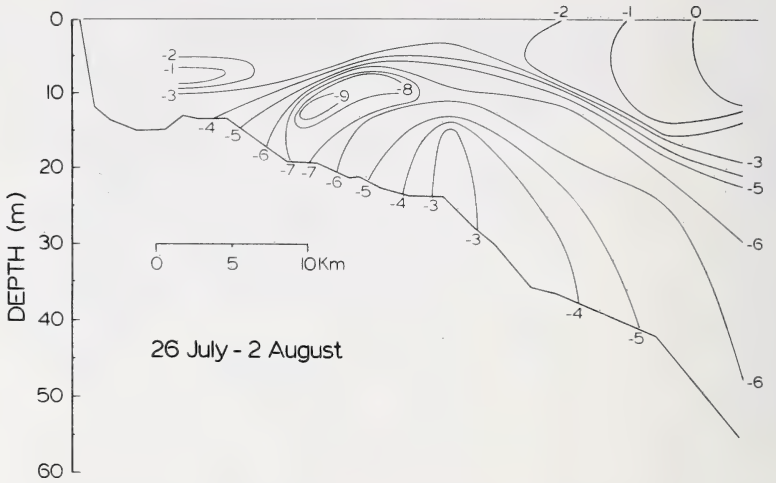

FIG. 11. Cross section of temperature differences (°C) recorded between 26 July and 2 August 1978. Negative values indicate a net cooling.

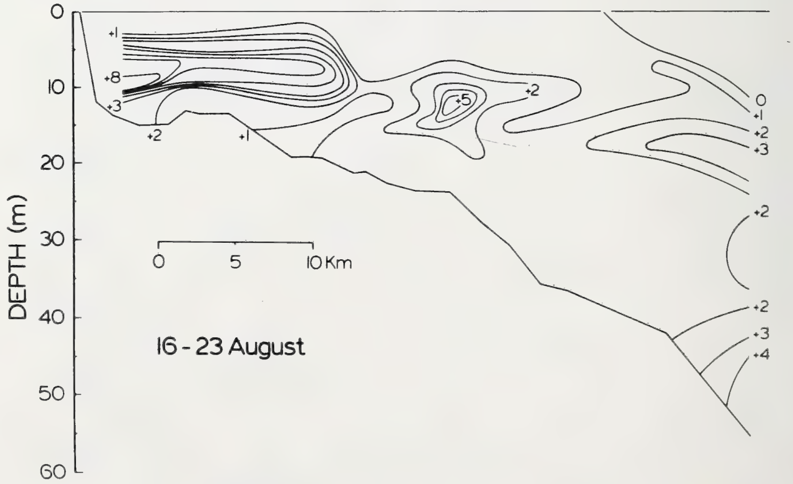

FIG. 12. Cross section of temperature differences (°C) recorded between 16 and 23 August 1978. Positive values indicate a net warming.

over 6 °C occurs in a band 10-20 m above the bottom over the middle and outer shelf. The highest value of just over 9 °C may be due to a rising of the thermocline as well as to the advection of cooler water. In the surface layer, a net cooling of around 2.5 °C over the inner and middle shelf gives way to no net change, and even to a slight net warming at the outermost station.

The cross section for 16-23 August (Fig. 12) shows a distinctly different pattern, with positive values indicating warming everywhere except in the upper 5-10 m at the outermost 2 stations. Strongest warming of over 8 °C at the inner station suggests that the breakdown of the upwelling pattern may originate at the coast and move seaward. The secondary maximum in warming over the middle shelf may reflect a slight vertical movement in the thermocline as much as advective warming.

Aside from documenting the summer upwelling along this part of the Florida Atlantic coast, this study was an attempt to determine the cause. Earlier studies (Green, 1944; Taylor and Stewart, 1958; Lemming, 1979) had postulated that upwelling was in response to coastal winds, but the correlation of coastal windstress and inner shelf bottom temperatures from a study site approximately 39 km to the south of this transect (Smith 1981) suggested that upwelling could not be explained in terms of simple Ekman dynamics alone. Bottom temperatures and coastal windstress were not significantly coherent over any time scale. Thus, in view of the probability that the Florida Current plays at least a supplementary role in driving the upwelling, near-bottom current and temperature data from mid shelf waters were compared to investigate the coherence and phase relationships between variations in the temperature and in the longshore component of the flow. The sampling station (27°30.0′N, 80°01.8′W) was at the 38 m isobath and approximately 25 km offshore of a point 46 km south of the transect shown in Figure 2. The sampling period for the current and temperature time series was 26 May through 29 July 1976; however, it is felt that the data represent typical summer conditions.

Figure 13 shows the coherence and phase spectra computed from the data collected 4 m above the 38 m isobath. The spectra have been plotted only through periods of 5 h, as the higher frequencies were not of interest. The coherence spectrum is not particularly encouraging, as values rise above the 90% confidence level only at 2 points (periods of approximately 2 and 5 da) in the low-frequency part of the spectrum. The positive phase angles, however, indicate that increases in current speed are followed by decreases in temperature with considerable consistency. Local wind data are not available for this part of the coast, thus the relative importance of windstress in driving the coastal upwelling cannot be estimated.

Discussion—On the one hand, the temperature cross sections suggest a substantial degree of persistence in the upwelling pattern over the course of the study. Especially between 2-30 August, upwelling appears to have maintained a strong thermal stratification, and with the exception of the last

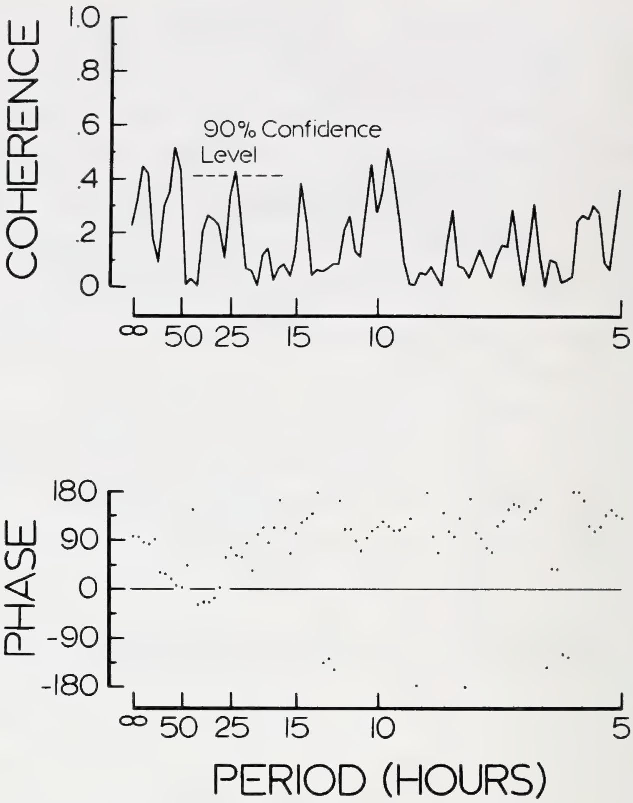

FIG. 13. Coherence and phase spectra of bottom temperatures and longshore currents, 26 May to 29 July 1976. Positive phase angles indicate a phase lead of increased northerly flow over decreased bottom temperatures. Spectral resolution is 0.0022 c.p.h.

week the 22° isotherm remained within 8 km of the coast—within the 15 m isobath.

On the other hand, the movement of the isotherms along the bottom in a cross-shelf direction (Fig. 10) indicates that the benthic boundary layer has considerable thermal activity during the summer months. The data show that significant changes can occur over a one-week period. Thus, to define the occurrence, characteristics and disappearance of upwelling more carefully, time series measurements would be required with a sampling period of a few hours at most, and over at least several weeks. Data more closely spaced in time would quantify more precisely the dominant time scales over which the incursions of water from the Florida Current, or in response to windstress, occur. Specifically, if upwelling is related to the Florida Current coming in contact with the outer shelf, then the time scales of upwelling events may be closely related to the quasi-periodic meandering of the streamlines. Kerr (1980) has documented quasi-periodic variations over time scales on the order of 2-3 da in current measurements from middle and outer shelf stations just south of the study area.

The mean position of the axis of the current (Fig. 2) is approximately 85 km offshore along this part of the coast. The position of the axis at a particular time may be quite variable, however. Chew and Berberian (1970) have recorded amplitudes in the streamlines on the order of 3 km at latitude 27°30'N, and Webster (1961) has reported amplitudes of 10 km off Onslow Bay at latitude 33°33'N. Futhermore, the wavelike pattern itself can be displaced east or west, and significant current speeds can extend several tens of kilometers in either direction across the Florida Straits. Thus, the outer end of the transect, 43 km offshore, can be expected to experience indirect effects of the current at least occasionally. This appears to be the case during much of the study, judging from the presence of relatively cool water and the downward slope of the isotherms in a seaward direction at the outer 1 or 2 stations.

The existence and probable dominance of the longshore component of the current in most shelf waters makes difficult an interpretation of Figure 10 in terms of shoreward or seaward advection of cool water. The local reversal of the bottom temperature gradient between 15 and 23 km from the coast on 2 August must be in response to a longshore advection of cooler water along the middle shelf, rather than a shoreward flow onto the middle shelf. The longshore flow over the outer shelf tends to be northerly throughout the year, due to the Florida Current, and southerly over the inner shelf during the summer months at least (Hale, 1976; Kerr, 1980; Smith, 1981), but the advective transport associated with this circulation is unknown.

Even in light of previous investigations of upwelling along the Atlantic coast of Florida, results presented here do not provide a definitive answer to the question of what is driving, maintaining and destroying upwelling in this region. Convincing evidence in a variety of forms, however, suggests that the Florida Current as well as Ekman dynamics may play a significant role. The consistent phase lead of increases in northerly flow over decreases in bottom temperature (Fig. 13) suggests a response to the current over time scales of several hours to several days at least. Whether this reflects a breakdown of geostrophy or flow along diverging isobaths is still unresolved. Furthermore, the part of the year during which upwelling has been documented and is reflected in the multiannual surf temperatures (Fig. 1) corresponds in a general way to that part of the year during which the mean wind vector is out of the southeast—a condition favorable for upwelling along a coastline oriented 160°-340°. The existence of 2 generation mechanisms, coupled with the low coherence to be expected between the local wind and the speed, direction and position of the Florida Current, may explain why neither process alone is particularly coherent with the observed upwelling. In addition, the time scale over which forcing occurs will have an effect on how far onto the shelf a particular upwelling event will proceed.

Conclusions—From the data made available by this study, it appears that upwelling events can occur with considerable speed in these shelf waters. The weekly interval between hydrographic surveys is about the maximum allowable period between site visits if the process is to be described adequately. It is clear that the entire shelf need not be involved in the shoreward excursions of cool water. Data obtained from only the inner shelf therefore may miss some events altogether and would not indicate the onset, nature and decay of upwelling events in every case. The study does not resolve questions relating to the seasonality of upwelling along this part of the coast, or the time scales associated with particular events. The data presented do suggest that the Florida Current, in addition to Ekman dynamics, plays an important role in governing the hydrography of Florida Atlantic shelf waters.

Acknowledgments—The assistance of George H. Kierspe, Lewis Gilliland and Dove W. Green III on the hydrographic cruises and in the analysis of the data is gratefully acknowledged. Lew Gilliland digitized the STD data and contoured the temperature and temperature difference cross sections. Robert O'Hagan directed the collection of the current and temperature data used to construct Fig. 13. This paper is Harbor Branch Foundation, Inc., Contribution Number 229.

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ROTULARIA VERNONI, AN ANNELID WORM TUBE FROM THE EOCENE OF PENINSULAR FLORIDA

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Abstract: *The type of species of the fossil annelid worm* Rotularia *Defrance, 1827, is* Serpula spirulaea *Lamarck, 1818, subsequently designated by Wrigley, 1951.* Rotularia vernoni *(Richards, 1948) is an excellent index fossil for the top zone of the Ocala Group (Eocene) of peninsular Florida.*

Richards (1948) described some annelid worm tubes from the top zone of the Ocala Group in peninsular Florida and named them *Spirulaea vernoni*. Because they are common, easily identified, and have limited stratigraphic range, Puri (1957) recognized the usefulness of this fossil and proposed the *Asterocyclina - Spirolaea* (sic) *vernoni* faunizone.

The problem has been that worm tubes designated as *vernoni* have been assigned to 2 different generic names in the older literature on the Eocene fossils and stratigraphy of Florida, but still another generic name seems to be the proper one. In the oldest literature (prior to 1948), *Tubulostium* Stoliczka, 1868, was the generic name that was consistently used for these distinctive annelid worm tubes. The date 1868 appears to be the correct one according to Ruhoff (1980), but Howell (1962) in the *Treatise on Invertebrate Paleontology* gave both 1868 and 1869 as the date of publication of the generic name *Tubulostium*. Richards (1948) assigned his trivial name *vernoni* to the generic name *Spirulaea* Bronn, 1827. This date is questioned by Sherborn (1922-1933), and he placed the date 1828 in parenthesis after 1827 in the reference to *Spirulaea*. Howell (1962) gave the date 1828 for Bronn's generic name *Spirulaea*. Wrigley (1951) stated that *Spirulaea* Bronn is preoccupied by Péron and Leseuer, 1807. However, *Spirulea* Péron and Leseuer is either a misspelling or an emendation of *Spirula* Lamarck (a cephalopod) according to Neave (1939–1940). We do not believe that *Spirulea* Péron and Leseuer, 1807, preoccupies *Spirulaea* Bronn, and the latter name appears to be available for these distinctive annelid worm tubes.

The name *Rotularia* Defrance was published in May 1827, according to Sherborn, and it is likely that it antedates *Spirulaea* Bronn. Defrance described four species of *Rotularia*, and the first one was *Rotularia complanata*, which he referred to *Serpula spirulaea* Lamarck, 1818, as a synonym. Apparently *Rotularia complanata* is a junior synonym of *Serpula spirulaea* Lamarck. Wrigley (1951) stated, "The earliest available name is

Rotularia Defrance, 1827, whose type is *Serpula spirulaea* Lam." This can be construed as a type designation by Wrigley and is the earliest we have been able to find. Howell (1962) cites *Serpula spirulaea* as the type species of *Rotularia*, but gives no indication of how the type species was fixed. The type species, *Rotularia spirulaea* (Lamarck), is found in beds of Cuisian (early Eocene) age in France.

Howell (1962) placed *Rotularia* in the Annelida, class Polychaeta, order Sedentaria, and family Serpulidae. Specimens of *Rotularia* are helically coiled, but the coiling is commonly so flat as to be nearly planispiral. The tube is about the same diameter throughout most of its length but ending at the apertural extremity in a restricted tube of smaller diameter, which extends outward tangentially from the coiled portion. The young stage of *Rotularia* was shell-cemented to some object on the substratum, but the adult stage appears to be unattached. Because *Rotularia vernoni* has been so infrequently figured, we have included 3 photographs (Fig. 1) of 2 specimens housed in the invertebrate paleontology collection at the Florida State Museum.

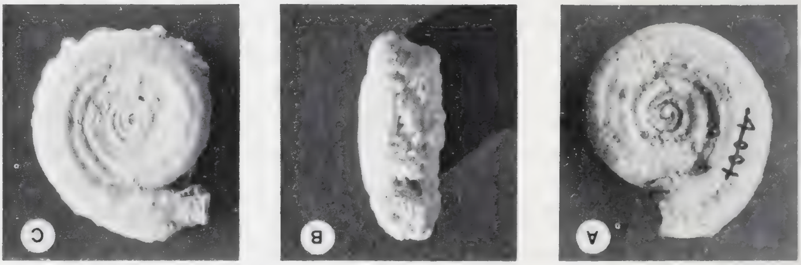

FIG. 1. Two specimens of *Rotularia vernoni* (Richards) from the Crystal River Formation of the Ocala Group, Upper Eocene, Florida. Both specimens housed in the invertebrate paleontology collection at the Florida State Museum. (A). Top view of specimen from quarry west of Dowling Park, Lafayette Co., Florida. Maximum diameter 19.4 mm. Catalogue #5294. (B). Side view of specimen from quarry east of Steinhatchee River near Tennille, Dixie Co., Florida. Maximum diameter 19.6 mm. Tube diameter at aperture 2.5 mm. Catalogue #5664. (C). Top view of specimen shown in (B).

Wrigley (1951) stated that the geologic range of *Rotularia* is from Cretaceous to early Oligocene, but the one record from the early Oligocene is from the Lattorfian, which is considered by some stratigraphers as either all or mostly late Eocene in age. The age of the Lattorfian is discussed by Pomerol (1973) and Davies (1975), and they are certainly not in agreement as to the age of the Lattorfian. Thus, the extension of the geologic range into beds of Oligocene age is in some doubt. Davies (1971) and Howell (1962) give the range of *Rotularia* as from Cretaceous to Eocene. *Rotularia vernoni* is one of the last species of the genus, occurring in the latest Eocene in peninsular Florida.

To catalogue all of the described species of *Rotularia* would be a difficult task for 2 reasons. Wrigley pointed out that species of *Rotularia* may be found under such generic names as *Serpula*, *Spirorbis*, *Vermicularia*, *Vermetus*, *Burtinella*, and *Solarium*, as well as *Tubulostium* and *Spirulaea*. Furthermore, these annelid worm tubes have been confused and classified with gastropods in many of the older faunal monographs. The number of described species of *Rotularia* is probably more than 30.

Gardner (1933, 1939) has described or reviewed at least 5 species of *Rotularia* from the Gulf coast area—*tobar*, *mcglameryae*, *horatianum*, *leptostoma*, and *cortezi*. Richards described the species *vernoni* from Florida in 1948. *Vermetus rotula* Morton from the Vincentown Formation of New Jersey (Weller, 1907) is almost certainly a species of *Rotularia*.

The geographic distribution of Rotularia is simply listed as cosmopolitan by Howell (1962) and Davies (1971). However, we have seen no species of *Rotularia* from the Cretaceous of the Gulf of Mexico and Atlantic coasts. The 7 species mentioned previously from the Gulf and Atlantic coasts are all found in either Paleocene or Eocene strata. On the other hand, species of *Rotularia* in Cretaceous strata have been described from Antarctica, the Falkland Islands, Patagonia, South Africa, New Zealand, Queenland, and India. A thorough study of fossil worm tubes, their morphology and distribution in space and time, most certainly would prove to be worthwhile from both a paleobiologic and a biogeographic-biostratigraphic standpoint. These fossils have heretofore received little attention from invertebrate paleontologists.

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Florida Sci. 45(2):139-142. 1982.

COQUINA SHELLS AS A SUPPLEMENTAL CALCIUM SOURCE IN LAYER HEN DIETS—*Richard D. Miles, Otto M. Junquiera, and Robert H. Harms,* Poultry Science Department, University of Florida, Gainesville, Florida 32611

ABSTRACT: *Two studies, 28 da each, were conducted to establish whether coquina shells could be used in laying hen diets as a source of calcium for egg shell formation. The coquina shell used in these studies analyzed 39% calcium and was from a 17 million-year-old natural deposit of shell located in a 0.9-1.5 m deep porous bed in St. Johns County, Florida. One-hundred and eighty individually-caged, 50 wk old White Leghorn hens (60 per treatment) were fed a typical commercial type layer diet containing approximately 3.4% calcium, 0.55% total phosphorus and 15.5% crude protein. Coquina shells replaced ground limestone in the experimental diets on a 0%, 50%, and 100% basis. In both studies no significant differences were observed in egg production, egg weight, shell weight, and specific gravity when the coquina supplemented diets were compared to the control. The amount of feed required to produce a dozen eggs was similar for all treatment groups. Coquina shells can be used as a supplemental source of calcium in layer diets.*

COMMERCIAL-LAYING hens need adequate available calcium for egg shell calcification purposes. Several materials are used in poultry feeds to furnish calcium. These include ground or granular oyster shells, ground limestone, and gypsum (calcium sulfate). Certain sources such as dicalcium and defluorinated phosphates also furnish available calcium to the hen.

Much of the early research concerned with calcium availability indicated that most of the calcium-containing materials were satisfactory sources for laying hens. Research also indicated that certain sources were better than others. Dougherty and Grossman (1923) reported that limestone supported better egg production than did oyster shell. Kennard (1925) reported that oyster shell was superior to limestone. In contrast to these reports, Buckner et al. (1923) found that limestone and oyster shell were equal as calcium sources for laying hens. Although calcium availability of feedstuffs does not vary greatly, it can be of some concern to the nutritionists. More recently Watkins et al. (1977) tested 3 calcium supplements (oyster shell, limestone and a mixed marine source) as completely ground material or as 33% ground plus 66% hen-size material in caged layer diets. No significant differences were found in egg production, feed consumption, feed efficiency, egg weight and egg shell strength when comparing different sources of calcium. Miller and Sunde (1975) reported that limestone, ground oyster shell, screened pullet size oyster shell, screened hen size oyster shell and screened coarse limestone were equal as a source of calcium for egg shell formation.

We wanted to determine if a native Florida product, coquina shells, could serve as an adequate source of supplemental calcium for laying hens.

Materials and Methods — Coquina shells used were from a natural deposit located in St. Johns County, Florida, approximately 18 km inland from the Atlantic coast. The shell was located in a bed 1.5 m thick covered with approximately 2 m of overburden. The shell was dredged, screened and washed. Carbon dating placed the age of the shell at 17 million yr old, and it was analyzed to contain 97% calcium carbonate and 0.1% magnesium carbonate, 0.26% moisture and 2.64 other (probably sand). Particle size of the coquina shells was such that 86% of the shells would pass through a screen with an opening diameter of 10 mm and 100% passing through a 12.5 mm opening. The specific gravity of the coquina shell was 1.82.

Table 1. Composition of control diet used in coquina shell study.

Ingredient	Percent of Diet
Ground Yellow Corn	70.70
Soybean Meal (50% CP)	19.00
Ground Limestone (38% Ca)	8.10
DynaFos (18.5% P, 24% Ca)	1.20
Microingredients	0.50
Iodized Salt	0.40
D. L. Methionine	0.10

One experiment, consisting of two 28 da periods, was conducted with a total of 180 White Leghorn hens (60 hens per treatment) which had been in production for 28 wk. Hens were individually-caged and fed a commercial type corn-soybean meal based diet. The control diet (Table 1) was calculated to contain 15.5% crude protein, 3.40% calcium, 0.55% total phosphorus and approximately 2880 Kcal of metabolizable energy per kilogram. The experimental diets and water were offered ad libitum. The coquina shell replaced ground limestone on a weight/weight basis in the control diet at levels of 0, 50, and 100%.

Results—Table 2 shows the results of both 28 da periods. Feed consumption during both periods was not significantly different between the hens fed the control and those fed the coquina supplemented diets. During the duration of the second period, the environmental temperature was lower and could explain the slight numerical increase in feed consumption during this period. No significant differences were found between egg production or feed efficiency during either period. Even though no significant differences were found between treatments for egg specific gravity, there was a slight numerical increase in egg specifc gravity for the diets supplemented with coquina shells. This observation was found to be consistent for each experimental period. Egg weight was slightly higher for the hens fed the coquina supplemented diets.

TABLE 2. Performance of laying hens fed diets supplemented and unsupplemented with coquina shells[1]

Treatment	Feed/Cons. (gm/hen/day)	Egg Production (%)	Feed Efficiency (Kg/doz)	Egg Specific Gravity	Percent Shell	Egg Wt. (g)
			STUDY 1			
Limestone	100.5	75.5	1.61	1.0816	9.24	63.83
Coquina + Limestone (50/50)	101.0	75.8	1.63	1.0829	9.39	64.09
Coquina (100%)	101.0	74.9	1.63	1.0832	9.48	64.07
			STUDY 2			
Limestone	102.1	71.6	1.76	1.0808	9.15	64.79
Coquina + Limestone (50/50)	103.5	73.5	1.75	1.0820	9.31	65.11
Coquina (100%)	102.2	72.8	1.72	1.0818	9.31	64.84

[1] No significant differences were found due to treatment.

Coquina shells can be used in layer diets as an adequate source of supplemental calcium by the hen without affecting overall performance or egg characteristics.

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FLORIDA SCIENTIST

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Biological Sciences

SEASONAL ABUNDANCE OF FISHES IN THREE NORTHWEST FLORIDA RIVERS

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ABSTRACT: *The seasonal abundances of 39 fish species in electrofishing collections were compared in the Escambia, Choctawhatchee, and Apalachicola rivers of northwest Florida. Relative abundances, as indicated by catch per unit effort of electrofishing, were examined in the Escambia River.* Lepisosteus osseus, Dorosoma cepedianum, D. petenense, *and* Mugil cephalus *were abundant during winter and spring high water in all 3 rivers, but seasonal patterns were less distinct in the larger Apalachicola. These seasonal euryhaline fishes and the catostomids contributed the greatest amounts to the fish biomass in the Escambia River. The abundance of* Carpiodes cyprinus *declined in the fall during low water, despite increased catch rates of other resident fishes. Female* C. velifer *outnumbered males during summer, but in winter sex ratios approached 1:1. Male* C. velifer *were more numerous downstream in late summer. A mark-and-recapture study of* Moxostoma poecilurum, *a dominant resident in the Escambia River, indicated 1095 ± 504 in a 1 km segment of the Escambia River.* Lepomis macrochirus *and* L. megalotis *were 2 of the most abundant fishes in the Escambia River.*

THE fish communities of temperate rivers change throughout the year as temperatures, flow, and day-length affect reproductive behavior, including migrations (Schwassmann, 1971), and as changing water levels induce other movements. Reproduction produces pulses of young fishes of different species at different seasons. However, long-term residence of some fishes imparts stability to stream communities. Most individuals of most species are residents in a small area of a stream (Gerking, 1950, 1953; Funk, 1955).

In the first part of this study we attempted to gain information on the structure and seasonal changes of the fish community of the Escambia River in the vicinity of the Florida-Alabama border. A complete list of fishes collected at the Escambia River in 1971-72 is given by Beecher et al. (1977). The second part of the study, which was carried out in conjunction with a study of *Carpiodes cyprinus* and *C. velifer* (see Beecher, 1979), compared

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[1] Present Address: Washington Department of Game, 600 N. Capitol Way, Olympia, Washington 98504.

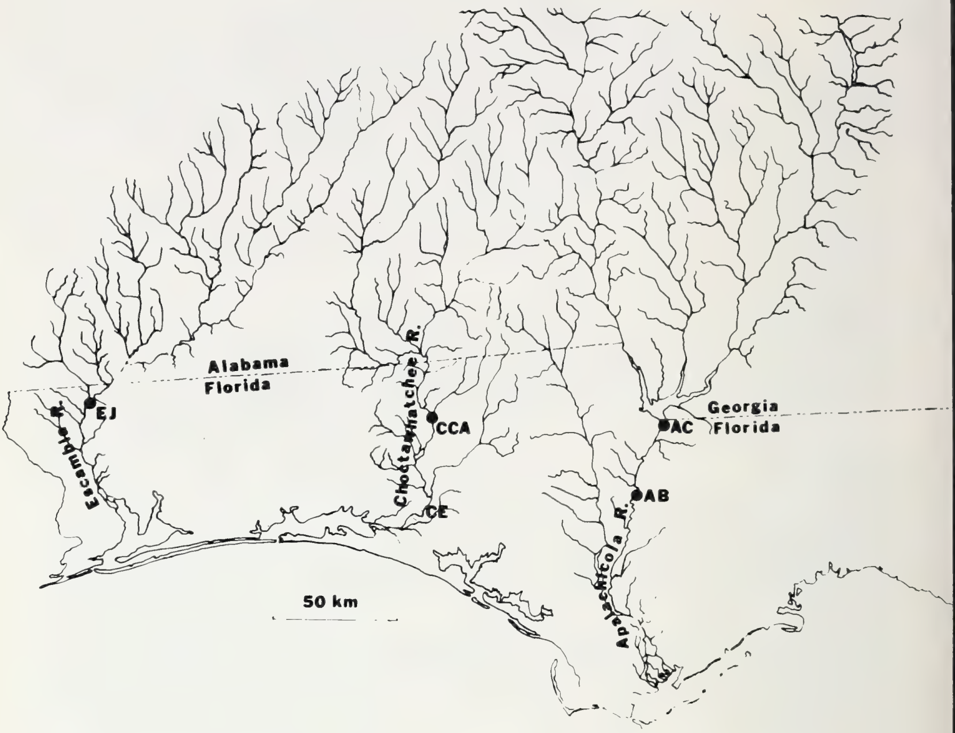

FIG. 1. Locations of study sites.

Escambia River seasonal patterns to patterns in 2 other northwest Florida drainages, the Choctawhatchee and Apalachicola rivers. A comparison of seasonal patterns in 2 different years at the Escambia River site was also made.

Few other studies have dealt with the community structure of large fishes in warm-water streams (e.g., Funk and Campbell, 1953; Gerking, 1950; Hansen, 1973). Tagatz (1968) indicated seasonal abundance of euryhaline fishes of the St. Johns River. Hellier (1967) collected and observed fishes of the clear, spring-fed Santa Fe River in the Suwannee drainage.

DESCRIPTION OF STUDY AREA—The locations of the 4 primary stations are shown in Fig. 1, and drainage parameters are shown for 3 of these stations in Table 1. The fourth station (AB) is 40 km downstream from station AC, and the Apalachicola River receives no tributaries larger than intermittent third order streams in that distance.

The Apalachicola River, the largest of the 3 streams studied, is a seventh order stream, the Choctawhatchee River is a sixth order stream, and the Escambia River is a fifth order stream (determined from U.S. Geological Survey 1:250,000 topographic maps) according to the Horton stream classification (Kuehne, 1970). The Choctawhatchee and Escambia rivers, which

Table 1. Drainage parameters of stations on the Escambia, Choctawhatchee, and Apalachicola rivers.[1]

Station	EJ	CCA	AC	AB
Drainage	Escambia	Choctawhatchee	Apalachicola	Apalachicola
Location	30 57′N 87 14′W	30 46′N 85 49′W	30 42′N 84 51′W	30 42′N 85 00′N
Elevation (m)	8.6	11.9	12.4	–
Distance from mouth (km)	84	106	164	124
Drainage area (km²)	9,880	9,050	44,300	–
Mean discharge (m³/sec) Oct 1971-Sept 1976	244	189	776	–
Minimum discharge (m³/sec) Oct 1971-May 1977	17	25	265	–
River height fluctuation (m) Oct 1971-May 1977	6.5	5.5	8.2	–
Stream Order	5	6	7	7

[1] Courtesy of U.S. Geological Survey, Tallahassee sub-district office.

have similar drainage areas and flows (Table 1), are part of a common faunal block (Bailey et al., 1954; Smith-Vaniz, 1968).

On the Escambia River, station EJ corresponds to station 14 of Bailey et al. (1954). The first part of the study concentrated on a 1 km segment of the river at this station (see Beecher et al., 1977), while in the later study collections at this station ranged over 18 km of the river.

At stations EJ, CCA, and AB, as well as at supplementary station CP, sandbars extended along the shore at the insides of bends (slip banks). The greatest depths at these stations were at the outsides of bends (cut banks) where steep banks were often overhung by fallen trees. The substrates were predominantly sand or clay-sand, while occasional patches of gravel occurred only at EJ. At high water the rivers inundated adjacent swamps.

At low water the maximum depths were 2-3 m at stations EJ and CCA. A navigation channel of 4-5 m is maintained in the Apalachicola River. Maximum depths which we encountered were 7-8 m at EJ and CCA, although higher flows occurred during the study. In the Apalachicola River depth at high flow was 5-6 m greater than at low flow, producing a maximum depth of about 10 m. Exceptionally deep holes at any of the stations could have exceeded these maximum depths.

The upstream boundary of station AC was Jim Woodruff Dam at Chattahoochee, Florida, and we covered approximately 5 km downstream. The substrates at station AC included sand, mixed sand and gravel, clay, and limestone.

Methods—Fish were collected with a boat-mounted 230V 60Hz shocker that put out 1.5-8 amps, and with 2 gill nets. The most frequently used gill net was a 30.5 m nylon monofilament net with mesh size ranging from 3.5-9.0 cm stretch mesh, and the other was a 61 m cotton net with mesh size ranging from 7.6-12.7 cm stretch mesh.

During the first part of the study we shocked a 1 km segment of the Escambia River at station EJ at least once each month from January through early December 1972. The total electrofishing effort on this segment was 68.1 h, excluding several supplementary collections outside the 1 km segment. Two netters, using long-handled dip nets with a 1 cm stretch mesh in the bag of the net, attempted to net all fish. Fish were placed in a circulating holding tank, and at the end of each electrofishing run each fish was identified to species, weighed to the nearest g, measured (cm SL), tagged (if larger than 10 cm SL and appearing healthy) with a Floy tag, and released. During early July we shocked the 1 km segment 13 times in 17 da, accounting for 28.2 h, in an attempt to increase tag returns.

Seasonal variation in depth affected the efficiency of our electrofishing. Electrode cables were 3.5 m long, but they reached this depth only when the boat was stationary with reference to the water. The electric field may have extended another 1-2 m below the cables. The electrofishing apparatus used in the first part of the study on the Escambia River was somewhat more efficient, especially during high flow, because of maneuverability. The effect of seasonal variation in electrofishing depth and efficiency upon our results is discussed under Seasonal Dominance in the Escambia River and Community Structure in the Escambia River, following Species Accounts.

In the second part of the study, gill nets were set for 197 h at EJ, 24 h at CCA, 16 h at CP, and 17 h at AC. Electrofishing effort was 26 h at EJ, 40 h at CCA, 25 h at AB, and 11 h at AC. The primary objective of the study was collection of carpsuckers (*Carpiodes cyprinus* and *C. velifer*). Other species were sight identified, but specimens were neither captured nor counted. The small effort at station AC was related to the ease of collecting *C. cyprinus* at this station: a monthly sample of 10 specimens was often collected in less than an hour.

Funk and Campbell (1953) discussed the selectivity of different collecting methods for large fishes, and Hansen (1973) noted that electrofishing was especially effective on carpsuckers and carp, but relatively ineffective on catfish.

SPECIES ACCOUNTS

ACIPENSERIDAE—sturgeons

Acipenser oxyrhynchus Mitchill. Atlantic sturgeon.

One sturgeon was shocked in early October 1972 in the Escambia River, but its size (ca. 2 m) precluded capture (Beecher et al., 1977). No sturgeon were observed during subsequent electrofishing or gill netting in any of the 3 streams. The occurrence of the Atlantic sturgeon in the Apalachicola River was discussed by Swift et al. (1977).

LEPISOSTEIDAE—gars

Lepisosteus oculatus (Winchell). Spotted gar.

This gar was uncommon in mainstream collections in all 3 rivers, with no evidence of seasonality in this study (Fig. 2, Table 2) nor in electrofishing studies by Florida Game and Freshwater Fish Commission personnel (Cox et al., 1975).

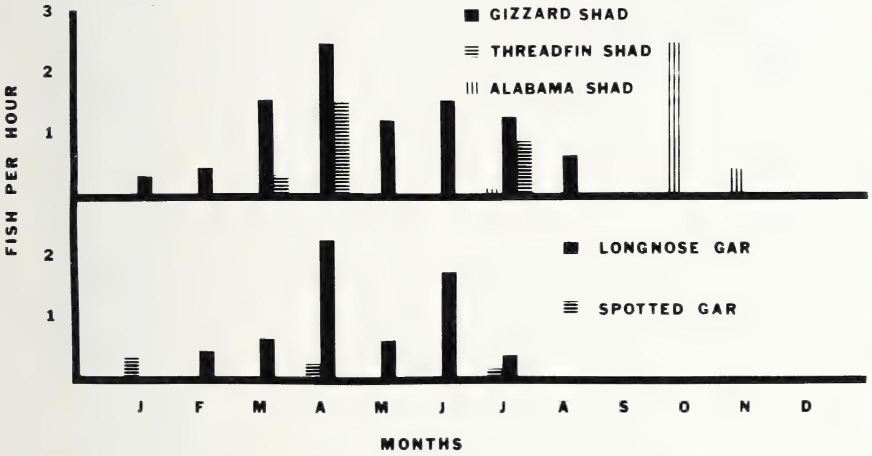

FIG. 2. Numbers of spotted and longnose gar (bottom) and threadfin, gizzard, and Alabama shad (top) caught per hour of electrofishing each month during 1972 at station EJ on the Escambia River.

Lepisosteus osseus (Linnaeus). Longnose gar.

The longnose gar was dominant in all 3 rivers during winter, spring, and early summer, when water level and turbidity were high (Table 2). It was the largest common fish, but other fishes were more numerous. In the Escambia it was absent for the remainder of the year during low water (Figs. 2, 9). In the Choctawhatchee the longnose gar was observed regularly from March to September 1976 and from February to April 1977. It was abundant in April and common in September. None were observed on 31 October or 9 December, but a single longnose gar was shocked on 7 November. November was the only month in which the longnose gar was not observed at station AB on the Apalachicola, but at the altered environment of station AC it was observed in every month (Table 2).

The longnose gar outnumbered the spotted gar 47:5 in the Escambia River during 1972, and in March and June it constituted more than 40% of the electrofishing catch by weight. Catch rates were probably conservative estimates of the abundance of gars because many escaped from the electric field and from the holding tank. We observed many gars rolling at the sur-

TABLE 2a. Seasonal occurrence of fish species in gill net (G) and electrofishing (E) operations in the Escambia River at station EJ, 1975-77. + indicates that a species was observed in a collection; numerals indicate number of specimens collected.

Date Collection Method Species	8-9Mar75 G	30May-1Jun G	4-6Jul G	17Apr76 G,E	23May E	10Jul E	7Aug E	9Oct E	13Nov E	10Dec76 E	8Jan77 E	5Feb G,E	20Mar E	9Apr E
Lepisosteus oculatus	–	4	–	–	–	–	–	–	–	–	–	–	–	–
L. osseus	9	14	6	+	+	+	+	–	–	–	+	+	+	+
Amia calva	–	–	–	–	–	+	+	–	+	+	+	+	–	+
Alosa alabamae	–	–	–	–	–	+	–	–	–	–	–	–	–	–
A. chrysochloris	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Dorosoma cepedianum	–	–	–	+	–	–	+	–	+	–	–	–	–	+
D. petenense	3	–	–	–	–	–	–	–	–	–	–	–	+	+
Esox niger	1	–	1	–	+	–	+	–	+	–	–	–	+	+
Notropis venustus	–	5	1	+	–	+	+	–	–	–	–	+	–	+
Carpiodes cyprinus	4	–	–	1	–	4	–	–	–	1	–	1	1	–
C. velifer	4	7	5	7	–	4	4	1	9	–	5	2	2	4
Erimyzon tenuis	–	–	–	–	–	–	–	–	–	+	–	–	–	–
Minytrema melanops	4	1	–	–	–	–	–	–	–	–	–	–	–	–
Moxostoma poecilurum	2	2	1	–	–	+	–	–	+	+	+	+	+	+
M. carinatum	–	–	–	–	–	–	+	–	–	+	–	–	–	–
Ictalurus nebulosus	–	–	–	–	–	–	–	–	–	–	–	–	–	+
I. punctatus	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Strongylura marina	–	–	–	–	–	+	–	–	–	–	–	–	–	–
Lepomis gulosus	–	1	–	–	–	–	–	–	+	–	–	–	–	–
L. macrochirus	–	–	–	+	–	–	–	+	+	+	+	+	+	+
L. megalotis	–	–	1	+	+	+	+	–	–	–	–	–	–	+
L. microlophus	–	2	1	–	–	–	+	–	–	–	–	–	–	–
L. punctatus	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Micropterus punctulatus[1]	1	2	–	+	–	+	–	–	–	–	–	–	+	–
M. salmoides[1]	–	1	–	+	–	+	–	–	–	–	–	–	+	–
Pomoxis nigromaculatus	–	1	–	–	–	–	–	–	–	–	+	+	–	–
Mugil cephalus	–	–	–	+	–	+	+	+	–	–	–	–	–	+

[1] Species not differentiated in electrofishing collections.

TABLE 2b. Seasonal occurrence of fish species in gill net (G) and electrofishing (E) operations in the Choctawhatchee River at station CCA, 1976-1977.

Date Collection Method Species	22Mar76 E	2Apr E	18Apr E,G	29Apr E	11May E	20May E	1Jun E	29Jun E	13Jul E	17Aug E	21Sep E	31Oct E	17Nov E	9Dec E	12Feb77 E,G	12Mar E	2Apr E
Lepisosteus oculatus	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–
L. osseus	+	+	+	+	+	+	+	+	+	+	+	–	+	–	+	+	+
Amia calva	–	–	–	–	+	–	–	–	–	+	+	+	+	+	+	–	–
Anguilla rostrata	–	–	–	–	–	–	–	+	+	+	+	–	–	–	–	–	–
Alosa chrysochloris	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Dorosoma cepedianum	–	+	–	+	–	–	–	–	–	+	+	–	–	+	–	–	–
D. petenense	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	+
Esox niger	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+
Notropis venustus	–	–	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Carpiodes cyprinus	1	–	2	2	2	2	1	–	1	2	1	1	–	–	5	2	–
C. velifer	–	–	6	10	4	3	12	8	7	14	10	18	22	19	14	–	–
Minytrema melanops	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+
Moxostoma poecilurum	+	–	+	–	+	+	–	+	+	+	+	+	+	+	+	–	+
Ictalurus nebulosus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+
Strongylura marina	–	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
Lepomis macrochirus	–	–	–	–	+	+	–	+	–	+	+	–	+	–	+	–	–
L. megalotis	–	–	+	–	+	–	+	+	+	+	–	+	–	–	–	–	–
L. microlophus	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–
Micropterus spp.	–	–	+	–	–	+	+	–	–	+	+	–	+	–	–	–	+
Pomoxis nigromaculatus	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–
Mugil cephalus	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–

TABLE 2c. Seasonal occurrence of fish species in electrofishing operations in the Apalachicola River at station AB, 1976-1977.

Date Species	2Apr76	20Apr	29Apr	20May	29Jun	22Jul	10Aug	23Sep	13Oct	26Nov	12Dec	12Jan77	13Feb	18Mar	2Apr
Lepisosteus oculatus	–	–	–	–	–	+	–	–	–	–	–	–	+	–	–
L. osseus	+	+	+	+	+	+	+	+	+	–	+	+	+	+	+
Amia calva	–	–	–	–	+	+	–	+	+	–	–	–	+	+	–
Anguilla rostrata	–	+	–	–	+	+	–	–	+	+	–	–	–	–	–
Alosa alabamae	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Dorosoma cepedianum	+	+	–	+	+	+	+	+	+	+	+	–	+	+	+
D. petenense	–	+	–	+	+	–	–	–	–	+	+	–	+	+	+
Cyprinus carpio	–	+	+	–	–	–	+	+	+	–	–	–	+	–	–
Notropis venustus	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–
Carpiodes cyprinus	–	3	1	2	–	–	–	2	3	3	3	–	–	6	3
Minytrema melanops	–	+	–	–	–	+	–	+	+	–	–	–	–	–	–
Moxostoma sp.	–	–	+	–	–	+	+	+	+	+	+	–	–	–	–
Ictalurus nebulosus	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–
I. punctatus	–	+	–	–	+	–	+	–	+	–	–	–	+	–	+
Strongylura marina	–	–	–	–	–	–	–	+	–	–	–	–	–	+	–
Morone chrysops	–	–	–	–	–	–	+	–	–	–	+	–	–	–	+
M. saxatilis	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–
Lepomis auritus	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–
L. macrochirus	+	+	–	+	+	+	–	+	–	–	–	–	+	+	+
L. microlophus	–	–	–	–	–	–	+	–	–	–	–	–	+	+	–
Micropterus spp.	–	+	–	–	+	+	+	–	–	+	–	–	–	–	+
Mugil cephalus	–	–	+	–	+	+	+	+	+	–	–	–	–	+	–
Paralichthys lethostigma	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–

TABLE 2d. Seasonal occurrence of fish species in gill net (G) and electrofishing (E) operations in the Apalachicola River (station AC) below Jim Woodruff Dam near Chattahoochee, Florida, 1975-1977.

Date Collection Method Species	28Jan75 G,E	12-13Feb E	26Mar G	6May E	20Apr76 E	11May E	1Jun E	13Jul E	17Aug E	21Sep E	31Oct E	17Nov E	9Dec E	11Jan77 E	13Feb E	18Mar E
Lepisosteus oculatus	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
L. osseus	–	+	7	+	+	+	+	+	+	+	+	+	+	+	+	+
Amia calva	1	+	–	+	–	+	–	–	+	–	–	–	–	–	–	–
Anguilla rostrata	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Alosa chrysochloris	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dorosoma cepedianum	5	+	2	–	–	–	+	+	–	–	+	–	+	+	+	+
D. petenense	–	+	–	–	–	+	+	–	–	–	–	–	–	–	–	+
Esox niger	2	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyprinus carpio	1	–	–	–	–	+	–	–	+	+	–	+	+	–	+	+
Notropis venustus	–	+	–	–	–	–	–	–	–	–	–	–	–	–	+	–
Carpiodes cyprinus	6	9	–	1	10	10	15	9	9	10	11	11	12	2	9	10
Erimyzon sucetta	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Minytrema melanops	5	–	–	–	–	–	–	+	–	–	–	–	–	–	+	–
Moxostoma sp.	2	+	–	–	–	–	–	–	–	–	–	–	+	–	–	+
Strongylura marina	–	+	–	2	–	–	–	+	–	+	–	–	–	–	–	+
Morone chrysops	1	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+
M. saxatilis	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Lepomis gulosus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–
L. macrochirus	–	+	–	–	–	–	–	–	–	–	–	–	–	–	+	–
L. microlophus	1	+	–	–	–	–	+	–	+	+	+	–	+	–	–	+
Micropterus spp.	–	+	–	–	–	–	–	+	–	–	–	–	+	–	–	–
Pomoxis nigromaculatus	4	+	–	–	–	+	–	+	–	+	–	–	+	–	+	–
Mugil cephalus	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–

face, gulping air, during months of collection, but saw none during low water in the fall when they were absent from our catch.

A melanistic individual was seen but not captured at station AC on 20 April 1976.

AMIIDAE—bowfins

Amia calva Linnaeus. Bowfin.

The bowfin, a year-round resident in all 3 rivers, was abundant from late fall through winter and spring in the Escambia River (Fig. 9, Table 2). The pattern was evident in 1976-77 as well as in 1972 (2 winters: '71-72 and '72-73) in the Escambia River, but no seasonal pattern was apparent in the Choctawhatchee or the Apalachicola River.

ANGUILLIDAE—freshwater eels

Anguilla rostrata (Lesueur). American eel.

The American eel was most frequently observed during summer and fall months in the 3 rivers, although individuals were observed in other months (Fig. 9, Table 2). On 17 August 1976 we encountered a dense concentration of eels and highfin carpsuckers in an area of reduced current with a mud bottom at the mouth of a cypress slough in the Choctawhatchee River.

CLUPEIDAE—herrings

Alosa alabamae Jordan and Evermann. Alabama shad.

Alabama shad juveniles were collected in moderate numbers in the Escambia River in July, October, and November (Fig. 2). We did not collect Alabama shad in electrofishing operations in the Choctawhatchee River, and our only record of this species in the Apalachicola River was in April at station AB (Table 2). However, the abundance of clupeids in the Apalachicola River probably masked the abundance of this species, as we did not attempt to capture the many clupeids we shocked. Laurence and Yerger (1967) reported that adult Alabama shad occurred from late February through late April in the Apalachicola River, and that young-of-the-year moved gradually downstream during the remainder of the year.

Bailey et al. (1954) collected no Alabama shad from the Escambia River and suggested that it was rare. Our few specimens confirm its presence in the Escambia.

Alosa chrysochloris (Rafinesque). Skipjack herring.

We observed the skipjack herring only once in each of the 3 rivers (Table 2). However, the abundance of other clupeids may have masked the presence of this species at other times as we did not attempt to capture the many clupeids we shocked. Wolfe (1969) reported that the skipjack herring was abundant below Jim Woodruff Dam (station AC) during its spawning run from late December or early January through early April.

Dorosoma cepedianum (Lesueur). Gizzard shad.

In the Escambia River the gizzard shad showed a well-defined seasonal distribution. It occurred in small schools, usually consisting of fewer than 10 individuals, from January through August 1972 with a peak catch rate in April (Fig. 2). During 1976-77 Escambia River electrofishing operations the gizzard shad was observed in April, when it was common, and August, and a single individual was shocked in November (Table 2a).

No seasonal pattern was evident for gizzard shad in the Choctawhatchee River. The gizzard shad was abundant in the Apalachicola River except in January, when it was not observed because of flooding. At station AC we observed gizzard shad most frequently from December through March (Table 2). No seasonal pattern was evident at station AB.

Dorosoma petenense (Günther). Threadfin shad.

This shad was less numerous than its larger congener in the Escambia, but the 2 species co-occurred during March, April, and July (Fig. 2). In the Choctawhatchee threadfin shad were observed only in April (Table 2). Wigfall (1973) reported that the threadfin shad was abundant near the mouth of the Choctawhatchee during the week of 2-6 April 1973, when it occurred in 29 longnose gar stomachs out of 97 containing food and 196 examined.

In the Apalachicola the threadfin shad was abundant during winter months and was present throughout the year (Table 2; Cox et al., 1975).

ESOCIDAE—pikes and pickerels

Esox niger Lesueur. Chain pickerel.

The chain pickerel was uncommon, and no seasonal pattern was evident (Fig. 9, Table 2).

CYPRINIDAE—minnows

Cyprinus carpio Linnaeus. Carp.

The carp was introduced into the Apalachicola River drainage where it was observed irregularly throughout the year (Table 2), but it is absent from the Choctawhatchee and Escambia rivers. Because of its large size, it probably constitutes a significant fraction of the fish biomass in the Apalachicola.

Notropis venustus (Girard). Blacktail shiner.

This species, along with the weed shiner (*N. texanus*) and the longnose shiner (*N. longirostris*), was a dominant minnow in the Escambia and Choctawhatchee rivers throughout the year. In the Escambia River, the blacktail shiner was the most numerous fish and the weed shiner was the second most numerous fish during the first part of the study (Beecher et al., 1977). In the Apalachicola the blacktail shiner is a dominant minnow along with the bluestripe shiner (*N. callitaenia*). The blacktail shiner is one of the few native cyprinids large enough to be caught in a gill net. The small size of the larger specimens and the difficulty of effectively sampling any of the native minnows with a shocker render it difficult to assess the significance of their contribution to the biomass (Table 2). Small fish are less susceptible to electricity than larger fish because of a smaller voltage difference across a shorter distance (Edwards and Higgins, 1973), and they also recover faster than larger fish. Many small cyprinids passed through the mesh of our dip nets. Similar comments apply to darters (family Percidae), which were much less abundant than cyprinids (Beecher et al., 1977).

CATOSTOMIDAE—suckers

Carpiodes cyprinus (Lesueur). Quillback.

In the Escambia and Choctawhatchee rivers the catch rate for quillback declined during low water in the late fall when the catch rate peaked for other resident fishes, including the quillback's smaller and more numerous congener, the highfin carpsucker. The quillback catch rate in the Apalachicola did not decline at the same time (Fig. 3). However, during the period of rapidly decreasing water temperature in November-December 1976 there was some evidence for a short-range mass downstream movement of quillback at station AC. On 31 October (water temperature = 16 C), quillback were scattered through a 500 m section of the river below Jim Woodruff Dam, but none appeared from 500 to 1000 m below the dam, a situation typical of many previous collections throughout the summer. In contrast, on 17 November (water temperature = 13 C), the quillback was abundant from 500 to 1000 m downstream from the dam. On 9 December (water temperature = 10 C), we were unable to locate any quillback in the 1000 m below the dam, but they were abundant from 1200 to 2000 m below the dam.

Quillback catch rates at station AB on the Apalachicola, at the Choctawhatchee, and in 2 yr (1972 and 1976-77) at the Escambia were all of the same order of magnitude (Fig. 3). However, a chi-square test, using number of quillback caught, indicated that the catch at station AB (equivalent to 0.97 quillback/hr of electrofishing) was significantly higher than at station CCA on the Choctawhatchee (0.55 quillback/hr) or at the Escambia (0.31 quillback/hr) ($\chi^2 = 37.37$, df = 20, $P < .01$).

Jim Woodruff Dam had a concentrating effect on quillback as well as on other fish species in the Apalachicola. Quillback abundance (catch per hour of electrofishing) at station AC immediately downstream from the dam was many times that at any other station (Table 3), and often equalled or exceeded the highest catch rates of the elsewhere more abundant highfin carpsucker. Quillback abundance decreased sharply within 4 km downstream from the dam.

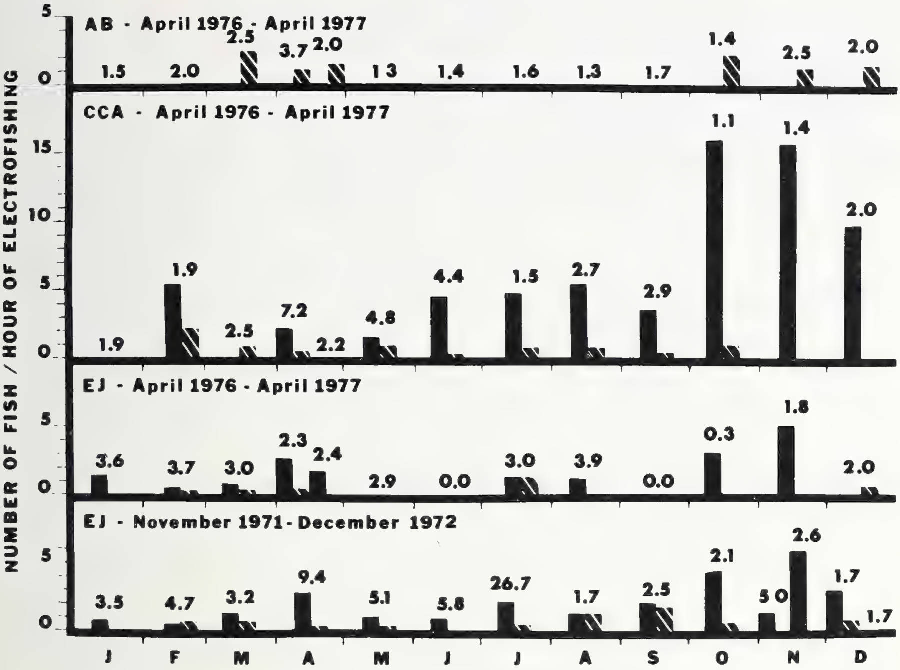

FIG. 3. Numbers of highfin carpsucker (black) and quillback (striped) captured per hour of electrofishing at stations on the Apalachicola, Choctawhatchee, and Escambia rivers (top to bottom). Figures above each month indicate numbers of hours of electrofishing effort.

Carpiodes velifer (Rafinesque). Highfin carpsucker.

The greatest catch rates for the highfin carpsucker occurred in October and November during low water in the Escambia and Choctawhatchee rivers, but we collected none in early December of 1972 or 1976 in the Escambia, despite continued low water and a high catch rate of other catostomids at that season (Figs. 3, 9).

Catch rates for the highfin carpsucker were similar in the 2 yr of electrofishing on the Escambia. The total catch rates at the Escambia and Choctawhatchee were compared using a chi-square test of numbers of fish caught each month. The total catch rate at the Escambia (equivalent to 1.7 highfin carpsucker/hr) was significantly less than at CCA on the Choctawhatchee (3.9 highfin carpsucker/hr) ($\chi^2 = 177.7$, df $= 26$, $P < .01$).

Sex ratios of the highfin carpsucker changed with season. At CCA and EJ, females outnumbered males during much of the year, but from October-November to March-April sex ratios approached 1:1 (Fig. 4). However, at station CE, a downstream site on the Choctawhatchee, males outnumbered females (7:2). The small sample size at CE did not permit rejection of a 1:1 sex ratio, but the number of males was significantly higher ($\chi^2 = 13.9$, df $= 1$, $P < .01$) than would be expected if the sex ratios at CE and CCA were the same. The highfin carpsucker does not occur in the Apalachicola River.

TABLE 3. Monthly catch rates for *Carpiodes cyprinus* at station AC compared to maximum catch rates for each species of *Carpiodes* at other stations. The number of hours of electrofishing effort is in parentheses.

Month	Station AC	Other Stations	
	C. cyprinus/hr	*C. cyprinus*/hr	*C. velifer*/hr
Apr 76	6.7[1] (1.5)	2.0 (1.5) AB	5.7 (1.7) CCA
May 76	7.0[1] (1.4)	1.5 (1.3) AB	2.2 (1.8) CCA
Jun 76	45.0 (1.3)	0.4 (3.6) CCA	4.6 (1.8) CCA
Jul 76	9.0 (1.0)	1.3 (3.0) EJ	4.7 (1.5) CCA
Aug 76	22.5 (0.4)	0.7 (1.7) CCA	5.2 (1.7) CCA
Sep 76	25.0 (0.4)	0.3 (2.9) CCA	4.6 (1.3) CE
Oct 76	16.5 (0.7)	2.0 (1.4) AB	16.4 (1.1) CCA
Nov 76	44.0 (0.2)	1.2 (2.6) AB	15.7 (1.4) CCA
Dec 76	8.6 (1.4)	1.5 (2.0) AB	9.5 (2.0) CCA
Jan 77	0.0 (1.7)	0.0 (1.8, 1.5, 3.7) AB, CCA, EJ	1.4 (3.7) EJ
Feb 77	8.2 (1.1)	2.1 (1.9) CCA	5.2 (1.9) CCA
Mar 77	10.0 (1.0)	2.4 (2.5) AB	0.7 (3.0) EJ

[1] In April and May at station AC electrofishing was continued after 10 fish were captured, and, although many additional *C. cyprinus* were seen, no effort was made to capture them.

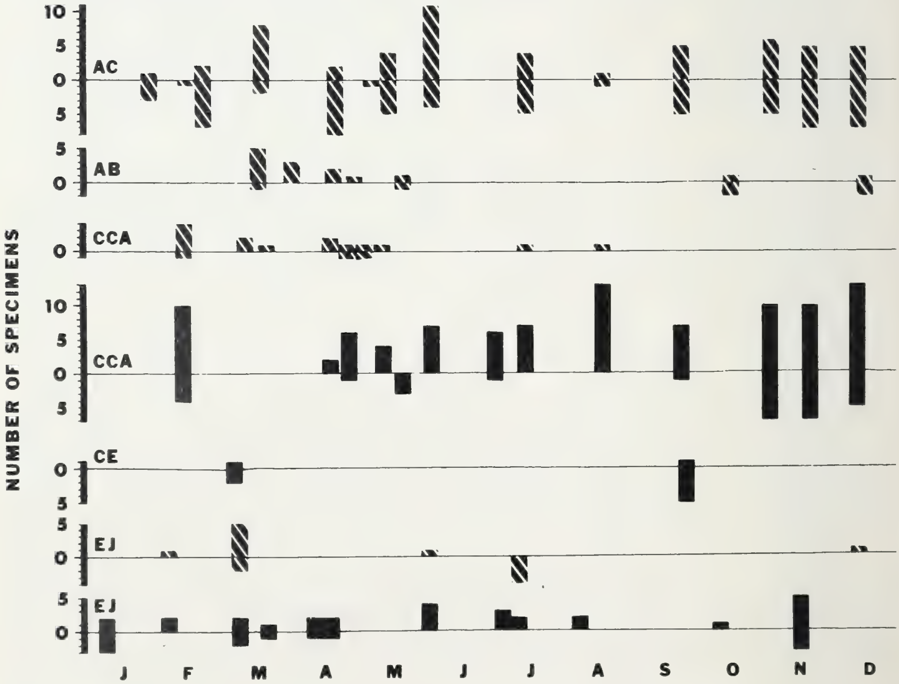

FIG. 4. Carpsucker sex ratios by season. Numbers of females (above horizontal lines) and males (below horizontal lines) of highfin carpsucker (black) and quillback (striped) in each collection at stations on the Apalachicola, Choctawhatchee, and Escambia rivers (top to bottom). Only adult fish were included in this figure. Letters at bottom indicate months.

Erimyzon sucetta (Lacépède). Lake chubsucker.

One specimen was gill-netted in the Apalachicola River at AC (Table 2d).

Erimyzon tenuis (Agassiz). Sharpfin chubsucker.

Five sharpfin chubsuckers were collected in the Escambia River during the summer of 1972 (Fig. 6) and one in December 1976 (Table 2a). None were observed in the Choctawhatchee. This fish is absent from the Apalachicola drainage (Yerger, 1977).

Minytrema melanops (Rafinesque). Spotted sucker.

This sucker was a year-round resident in all 3 rivers (Table 2), and the maximum catch rates occurred during low water in October and November in the Escambia (Fig. 6).

Among 4 specimens captured in gill nets in the Escambia on 8-9 March 1975 were a male with prominent breeding tubercles and a large gravid female. Swift et al. (1977) reported an aggregation of 14 spotted suckers in breeding condition below Jim Woodruff Dam (AC) in late March, and McSwain and Gennings (1972) described spawning activities of spotted suckers between March and May in Georgia tributaries of the Apalachicola drainage.

Moxostoma carinatum (Cope). River redhorse.

In the Escambia we collected single specimens of the river redhorse in February, July, and November 1972, and shocked but did not capture 2 others in August and December 1976. Yerger and Suttkus (1962) reported 8 specimens in a rotenone collection from the Escambia and suggested that this species might be expected from the Choctawhatchee. However, we did not observe the river redhorse in the Choctawhatchee, and Jenkins (1970) considered it unlikely to occur there. It does not occur in the Apalachicola (Jenkins, 1970; Yerger, 1977).

Moxostoma poecilurum (Jordan). Blacktail redhorse.

This redhorse was a common year-round resident in the Escambia and Choctawhatchee rivers (Table 2, Fig. 5). The 1972 catch rate was lowest at high water in March and greatest at low water in November (Fig. 5). A similar pattern was evident in the Choctawhatchee. This species does not occur in the Apalachicola (Jenkins, 1970; Yerger, 1977).

The blacktail redhorse was a dominant fish in the Escambia. During 6 months of 1972 (May, August-December), this was the dominant fish by weight in our electrofishing catch. Over the entire 1972 survey it constituted 16.5% of the weight of all fish shocked, and was second in weight only to the striped mullet (*Mugil cephalus*), a transient species. Only 2 sunfishes *(Lepomis macrochirus* and *L. megalotis)* and 2 minnows *(Notropis venustus* and *N. texanus)* exceeded it in numbers in our electrofishing catch.

Using the Schnabel mark-and-recapture method (Robson and Regier, 1971), we attempted to estimate the populations of all fish species in a 1 km long × 75 m wide segment of the Escambia, but only for the blacktail

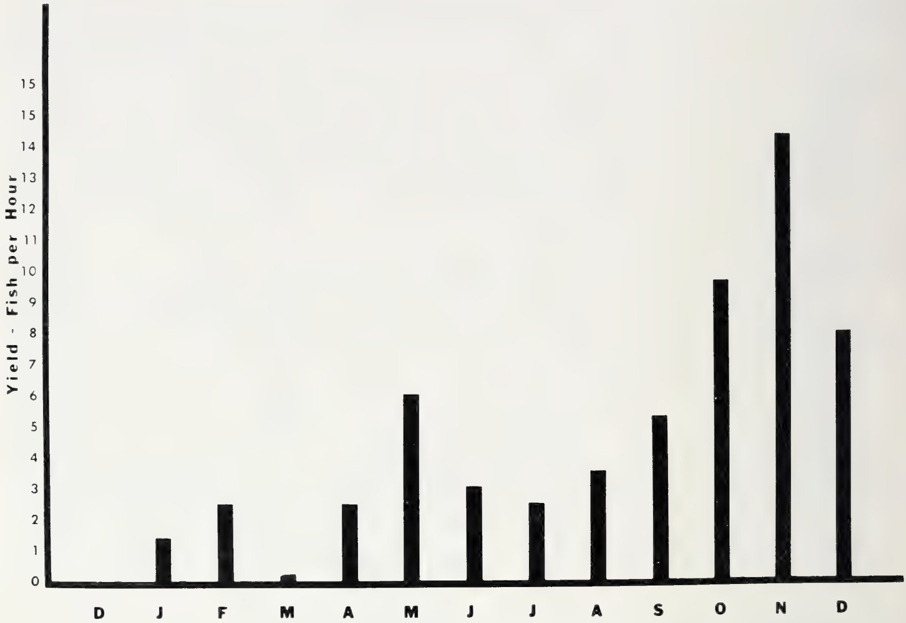

FIG. 5. Numbers of blacktail redhorse caught per hour of electrofishing each month during 1972 at station EJ on the Escambia River.

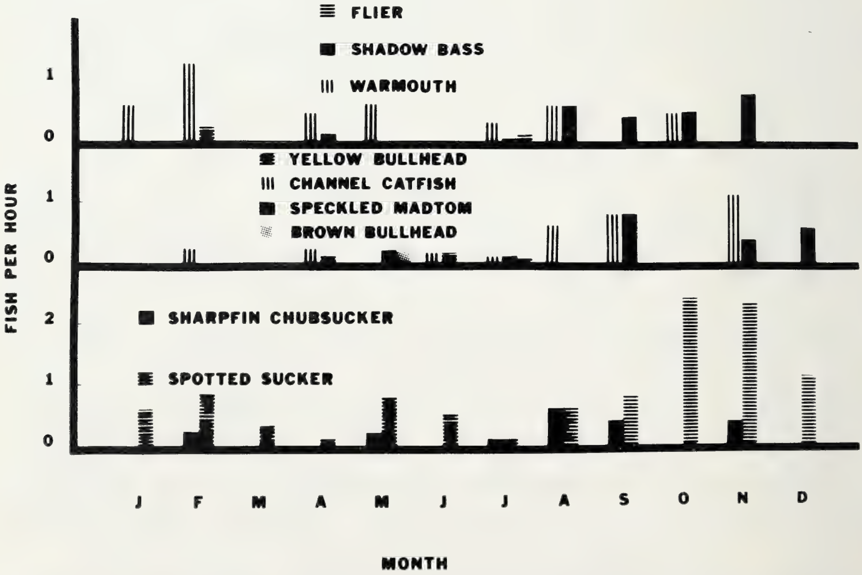

FIG. 6. Numbers of sharpfin chubsucker and spotted sucker (bottom), catfishes (middle), and flier, shadow bass, and warmouth (top) caught per hour of electrofishing each month during 1972 at station EJ on the Escambia River.

redhorse was the return sufficient to justify a population estimate. Our final estimate (based on 19 recaptures of 180 tagged individuals) for the blacktail redhorse population in the 1 km segment of the river was 1095 fish larger than 10 cm SL (Table 4). The seasonal distribution suggests that this species was resident in our study area (Table 4). The recapture of a fish which was tagged 26 December 1971 was not used in estimating the population because data from that tagging date were lost.

The highest incidence of injury and death among shocker-caught redhorse occurred in April-June, and appeared to be associated with spawning stress. Injuries were restricted to the ventral surfaces and fins in these months. A 28 cm SL, 405 g male captured on 9 April had a tuberculate anal fin and was shedding milt. A local sucker fishery exists in March and April in tributaries, coinciding with the months in which the blacktail redhorse constituted less than 10% of the number of fish caught.

Moxostoma species. Grayfin redhorse.

The grayfin redhorse is endemic to the Apalachicola drainage (Jenkins, 1970), where it occurred throughout the year at both stations (Table 2; Cox et al., 1975; Yerger and Suttkus, 1962). It was common in September and October at AB, especially along steep edges of sandbars in moderate current (ca. 0.3 m/sec). Fish collected in late March at AC were spawning (Yerger and Suttkus, 1962).

ICTALURIDAE—freshwater catfishes

Ictalurus natalis (Lesueur). Yellow bullhead.

Three specimens were captured during the 1972 Escambia River electrofishing survey (Fig. 6), but none were observed during subsequent collections in any of the 3 rivers.

Ictalurus nebulosus (Lesueur). Brown bullhead.

The brown bullhead was uncommon in electrofishing samples in all 3 rivers (Table 2, Fig. 6).

Ictalurus punctatus (Rafinesque). Channel catfish.

The channel catfish was the dominant catfish by weight and number in the Escambia in 1972 (Fig. 6), although it was probably under-represented in our catch because an AC shocker is less effective than a DC shocker for catfish (Hansen, 1973; Beecher et al., 1977). We collected no channel catfish in the Escambia or Choctawhatchee rivers in 1976-77. Yerger (1977) indicated that this species was plentiful in the Apalachicola in 1976, and, assuming our equipment was only minimally effective at catching them, our records concur (Table 2c). The ineffectiveness of the AC shocker on catfish was probably responsible for our failure to capture other catfishes (*I. brunneus, I. serracanthus, I. catus*) which occur in the Apalachicola River (Yerger, 1977) or *I. catus* from the other 2 drainages where it may occur (Smith-Vaniz, 1968).

TABLE 4. Results of mark-and-recapture study of blacktail redhorse (*Moxostoma poecilurum*) in a 1 km segment of the Escambia River near Jay, Florida, during 1972. N_S is the Schnabel estimate of the population size and SE(N_S) is the standard error of the estimate.

Date	Catch	Tagged Fish in Population	Recaptures	Dates of Previous Captures	N_S	SE(N_S)
08 Jan	4[1]	0	0	–	–	–
23 Jan	1	4	0	–	–	–
21 Feb	4	5	0	–	–	–
25 Feb	8	9	1	8 Jan	72	72
04 Mar	1	13	0	–	85	85
05 Mar	1	14	0	–	99	99
07 Apr	2	15	1	8 Jan	65	46
08 Apr	5	16	0	–	105	74
09 Apr	9	20	0	–	195	138
22 Apr	8	24	0	–	291	206
05 May	9	25	0	–	403	285
06 May	10	31	1	5 May	373	216
07 May	11	40	2[2]	5 May; 5 May; 26 Dec[2]	311	139
02 Jun	2	49	0	–	331	148
03 Jun	5	50	0	–	381	170
17 Jun	3	55	0	–	414	185
30 Jun	8	56	0	–	503	225
01 Jul	11	63	1	8 Jan, 7 Apr	535	220
02 Jul	5	73	1	1 Jul	511	196
03 Jul	3	77	0	–	544	207
04 Jul	4	80	1	30 Jun	516	183
05 Jul	2	82	0	–	536	190
06 Jul	3	84	0	–	568	202
08 Jul	1	87	0	–	579	206
10 Jul	3	88	1	6 May	544	181
13 Jul	11	90	2[3]	6 May, 10 Jul[3]; 30 Jun	535	161
14 Jul	7	98	0	–	597	180
15 Jul	5	105	1	14 Jul	591	171
16 Jul	8	109	2	5 May; 7 May	569	153
26 Aug	6	115	0	–	618	165
09 Sep	13	121	3	16 Jul; 3 Jun; 6 May	602	146
28 Oct	19	130	0	–	747	182
12 Nov	37	149	2	28 Oct; 7 Apr	959	221
03 Dec	14	180	0	–	1095	252
TOTALS	239[1]	180	19[2]			

[1] Fish captured on first date, 8 January, are not included in total catch because no usable tags occurred in the population at that time.

[2] A fish tagged on 26 December 1971 was recaptured, but could not be considered in population estimation because data from tagging date were lost.

[3] On 13 July a tagged fish died at the time of its second recapture.

A brown water snake (*Natrix taxispilota*), captured 13 July 1972 at EJ, had swallowed a juvenile channel catfish.

Noturus leptacanthus Jordan. Speckled madtom.

In the summer and fall of 1972 we collected 8 speckled madtoms in the Escambia River (Fig. 6). This was the second most numerous catfish, but its contribution to the biomass was negligible. It was absent from subsequent gill net and electrofishing catches in the 3 rivers.

BELONIDAE—needlefishes

Strongylura marina (Walbaum). Atlantic needlefish.

The Atlantic needlefish occurred in the Escambia in June and July, and in the Choctawhatchee in April and July, but it occurred throughout the year in the Apalachicola (Table 2). Swift et al. (1977) suggested that this fish reproduces in fresh water.

PERCICHTHYIDAE—temperate basses

Morone chrysops (Rafinesque). White bass.

The white bass, introduced into the Apalachicola drainage (Yerger, 1977), was collected irregularly throughout the year at AB and AC (Table 2). During late winter and early spring these fish, as well as artificial hybrids with striped bass, were abundant at AB and were approaching spawning condition (Steve Babcock, pers. comm.)

Morone saxatilis (Walbaum). Striped bass.

Although this fish has been reported from the Escambia and Choctawhatchee rivers, it is common only in the Apalachicola (Barkuloo, 1967). Yerger (1977) indicated that the native population in the Apalachicola River has been augmented by stocking.

At AB 2 specimens were collected in November, and at AC specimens were observed in February (Table 2). Barkuloo (1967) reported that the sport fishery for striped bass in the Apalachicola has 2 peaks, the spawning run from March-May, and mid-September to December.

CENTRARCHIDAE—sunfishes

Ambloplites ariommus Viosca. Shadow bass.

Seven specimens were collected from the Escambia in 1972, 6 between July and November (Fig. 6). None was seen in subsequent collections in the 3 rivers.

Centrarchus macropterus (Lacépède). Flier.

Three fliers were collected from the Escambia in 1972 (Fig. 6), and a single flier was gill-netted from the Choctawhatchee at CP, 7 km S of the Florida-Alabama border, on 25-26 March 1975. None was taken from the Apalachicola River.

Lepomis auritus (Linnaeus). Redbreast sunfish.

The redbreast sunfish was observed in October at AB on the Apalachicola River (Table 2c).

Lepomis gulosus (Cuvier). Warmouth.

The warmouth was taken irregularly throughout the year in the Escambia (Fig. 6), and was observed in February at AC on the Apalachicola (Table 2).

Lepomis macrochirus (Rafinesque). Bluegill.

The bluegill occurred throughout the year in all 3 rivers (Fig. 7, Table 2). It was the most abundant fish other than minnows in our electrofishing catch from the Escambia River in 1972 (Beecher et al., 1977). After the black basses (*Micropterus* spp.), the bluegill was the next most important centrarchid by weight and constituted 3.2% of the weight of shocker-caught fish. The catch rate peaked in April followed by a second peak in November (Fig. 7).

Lepomis megalotis (Rafinesque). Longear sunfish.

The longear sunfish occurred throughout the year in the Escambia and Choctawhatchee (Fig. 7, Table 2), but it is absent from the Apalachicola (Yerger, 1977). Peak catch rates for the longear sunfish coincided with those of the bluegill, and in May, June, August, September, and November 1972 it exceeded the bluegill in numbers in the Escambia (Fig 7; Beecher et al., 1977). It was the next most numerous fish after the bluegill in the 1972 Escambia River electrofishing catch, but because of its smaller size it constituted only 1% of the weight of shocker-caught fish. During 1972, when all fish were captured and carefully identified, we did not find any specimens of the similar-looking *L. marginatus.* Numerous seine collections at EJ, CCA, and CP during 1971-76 did not yield any specimens of *L. marginatus* (Beecher, unpublished data), leading us to believe that all specimens of the longear sunfish were correctly identified in the second part of this study.

Lepomis microlophus (Gunther). Redear sunfish.

The redear sunfish or shellcracker occurred throughout the year in all 3 rivers (Fig. 7, Table 2). Because of its large size (mean weight = 140 g, mean length = 13.5 cm SL), the redear ranked next after the bluegill in contribution to the weight of shocker-caught centrarchids.

Lepomis punctatus (Valenciennes). Spotted sunfish.

Only 3 spotted sunfish or stumpknockers were collected in the Escambia (Fig. 7, Table 2a), and none was seen at any of the 3 rivers during 1976-77 electrofishing operations.

Micropterus punctulatus (Rafinesque). Spotted bass.

During the 1972 Escambia River survey we were uncertain of the identification of many bass, most of which were tagged and released, and therefore unavailable for confirmations of identifications. We tentatively identified 23 specimens as spotted bass and 89 as largemouth bass (*M. salmoides*), and confirmed the presence of both species. In 1976-77 electrofishing operations at all 3 rivers bass were observed but seldom collected, and identifications were often doubtful. All bass will be discussed together under largemouth bass.

Micropterus salmoides (Lacépède). Largemouth bass.

As noted under the spotted bass, identifications of bass in this study were doubtful and all bass were discussed together. Bass occurred throughout the

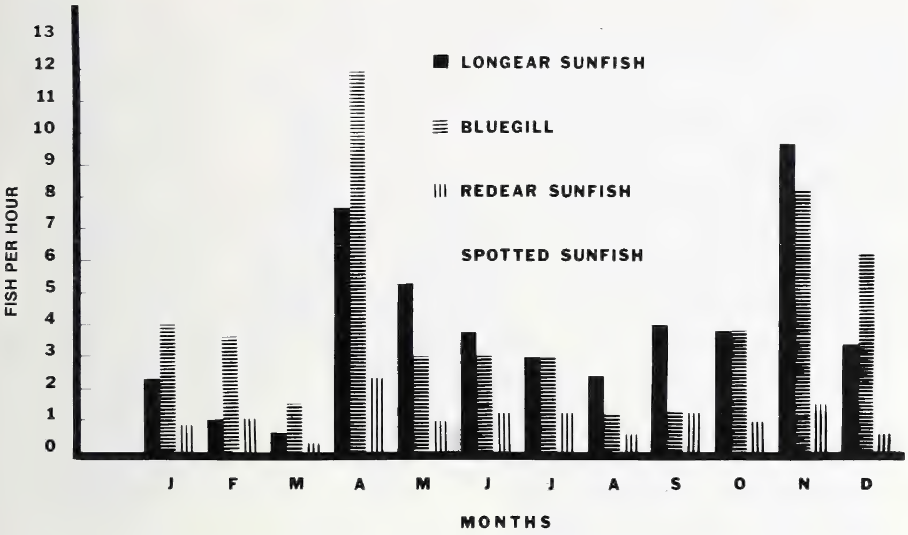

FIG. 7. Numbers of bluegill, longear sunfish, redear sunfish, and spotted sunfish caught per hour of electrofishing each month during 1972 at station EJ on the Escambia River.

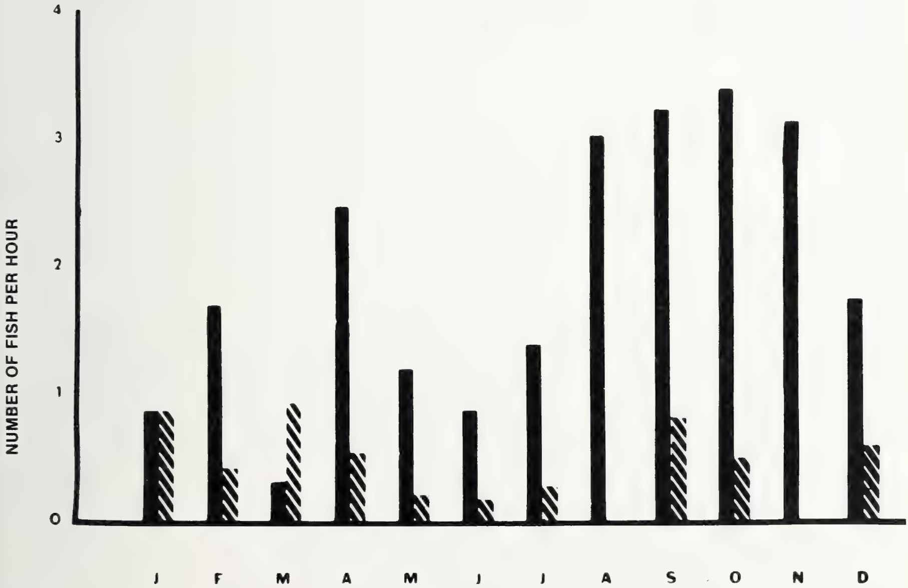

FIG. 8. Numbers of bass (black) and black crappie (striped) caught per hour of electrofishing each month during 1972 at station EJ on the Escambia River.

year at all stations (Fig. 8, Table 2). They dominated the 1972 Escambia River centrarchid catch by weight and constituted 5.1% of the electrofishing catch weight. In the Apalachicola, the undescribed shoal bass (*Micropterus* sp.) occurs along with the 2 previously listed species (Yerger, 1977) although none was identified in our catch.

Pomoxis nigromaculatus (Lesueur). Black crappie.

The black crappie occurred throughout the year in all 3 rivers (Fig. 8, Table 2; Cox et al., 1975). In 1976-77 electrofishing operations it was common in the Escambia only in January. In November, anglers caught a number of crappies in the Choctawhatchee, although we shocked crappies only in June and July in that river. In the Apalachicola we collected crappies only in January and February. The black crappie is a popular sport fish during the colder months when it is active preparatory to spawning (Swift et al., 1977). The white crappie (*P. annularis*) has been introduced in the Choctawhatchee River (Smith-Vaniz, 1968), and specimens could have been misidentified as black crappie.

MUGILIDAE—mullets

Mugil cephalus Linnaeus. Striped mullet.

The striped mullet was absent from all stations during late fall and early winter (Fig. 9, Table 2), coinciding with its offshore spawning season (Arnold and Thompson, 1958). At tidewater stations in the Escambia, it was more abundant in late October and early November than in Late March and early April (Bailey et al., 1954). The large number of individuals in the fall presumably corresponded to the exodus through the river mouth on the spawning migration. At CCA, which is 22 km farther from the mouth of the Choctawhatchee than is EJ from the mouth of the Escambia, the mullet was present only in July and August, compared to January through early October at EJ. Similarly, in the Apalachicola, mullet occurred from March through October at AB, but at AC, 40 km farther upstream, it was observed only in June and July (Table 2). Hellier (1967) and Tagatz (1968) indicated similar seasonal occurrences of the mullet in the Santa Fe and St. Johns rivers, respectively.

The striped mullet was the dominant fish by weight (29.8%) in the 1972 electrofishing catch. However, the dominance of mullet was exaggerated by increased collecting effort in July when mullet were most abundant. Escambia River mullet had a mean weight of 665.9 g and a mean length of 31.9 cm SL. Individuals and small schools (2-10) inhabited shallow sand bars and areas of reduced current.

BOTHIDAE—lefteye flounders

Paralichthys lethostigma Jordan and Gilbert. Southern flounder.

The southern flounder occurred throughout the year in the Escambia

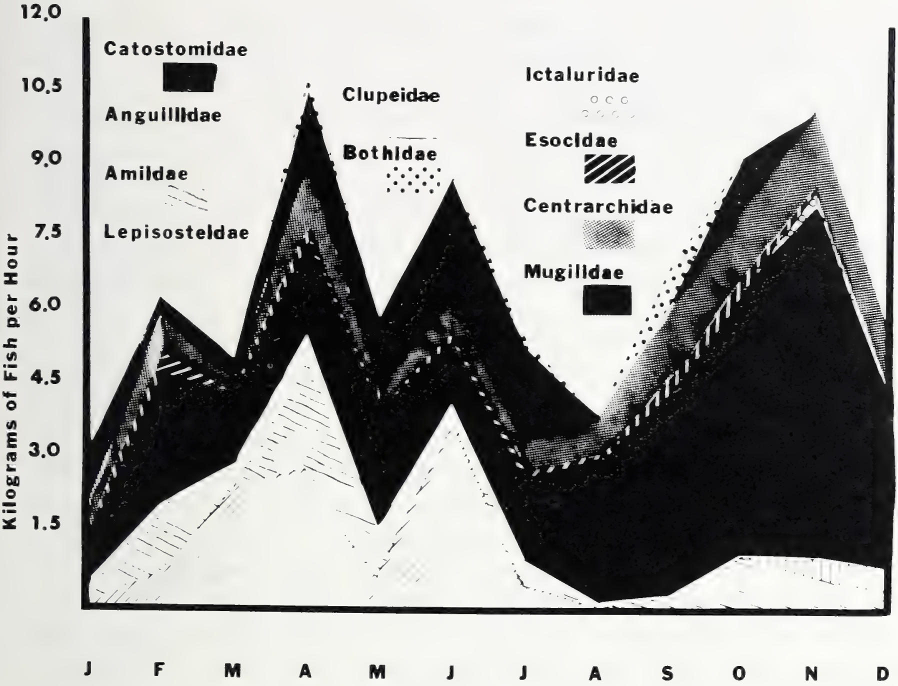

FIG. 9. Monthly catch rate by weight of families of fishes during 1972 in the Escambia River at station EJ.

and Apalachicola rivers (Fig. 9, Table 2; Cox et al., 1975), but was not observed in the Choctawhatchee. Nine specimens from the Escambia had a mean length of 34.6 cm SL and a mean weight of 1021 g.

SEASONAL DOMINANCE IN THE ESCAMBIA RIVER—Fishes of the Escambia River can be classified as (1) resident fishes occurring throughout the year, or (2) transient euryhaline fishes.

The bowfin, chain pickerel, cyprinids, catostomids, ictalurids, and centrarchids are residents at EJ. Catch rates of many of these fishes were greatest during low water from July or August through early December (Fig. 9). Reduced flow at this season concentrated the fish and rendered all depths vulnerable to electrofishing, while during periods of high water fish may be scattered over a broad area and beneath the depth reached by electrodes.

High water, from late December or January through July or August, was characterized by the dominance of several transient euryhaline species, particularly the longnose gar and the striped mullet (Fig. 9). In some months these 2 species constituted over 50% by weight of the electrofishing catch. These fishes were absent from the Escambia at low water, when fish were most catchable, and therefore this seasonal occurrence is real, not an artifact of collecting. Mullet presumably left the river in a spawning migration, but the movement of the longnose gar is less easily explained. The simultaneous absence of 2 dominant transients during low water, when water volume might otherwise become limiting, leaves that water volume to the resident freshwater fishes. This seasonal movement ensures that the community supports roughly the maximum sustainable fish biomass at any given season or flow.

The co-occurrence during high water of the longnose gar and the threadfin and gizzard shads is interesting in view of the demonstration by Wigfall (1973) and Summerfelt (1968, cited by Jester and Jenkins, 1972) that the longnose gar feeds heavily on threadfin and gizzard shad. The longnose gar may follow a major food source, the schools of clupeids, on their seasonal movements.

COMMUNITY STRUCTURE IN THE ESCAMBIA RIVER—Fall collections probably gave the most accurate samples. In October and November water levels in these streams reach the lowest levels of the year, between 10% and 30% of the mean discharge (Table 1). Resident fishes were concentrated in smaller areas and volumes, thus increasing the densities of these species. Consequently, our catch was greater during low water (Fig. 9; Beecher et al., 1977), and the larger sample size increased our chance of a representative sample. During these low-water periods the deepest areas at EJ were only 2 m deep and could be reached by the cable electrodes of our shocker. Bias against deep-dwelling fishes was minimized during low water, as shown by the increased catch of catfishes and eels (Fig. 9).

Catostomids were the dominant fishes by weight during the fall in 1971 and 1972. In August through early December 1972, catostomids constituted 60-70% of the weight of the electrofishing catch. They appeared to dominate in the fall of 1976, although data were not quantified for that year. Catostomids feed on small benthic invertebrates, diatoms, and organic detritus (Forbes and Richardson, 1909; Harlan and Speaker, 1956; Scott and Crossman, 1973; Beecher, 1979); thus they feed at a low tropic level, but are not first-order consumers.

Two other families, Clupeidae and Mugilidae, include fishes which feed at a low trophic level. *Mugil cephalus* and *Dorosoma* spp. are primary consumers, but are only seasonal members of the fish community of the upper Escambia River. Another clupeid, *Alosa alabamae*, feeds at a higher trophic level, but it is rare. Mullet reached maximum abundance when long days and warm weather coincided with high water in June and early July, probably resulting in high primary production in the river and adjacent swamp.

Centrarchids were the second most important family by weight in fall collections in the upper Escambia River. A few large bass (*Micropterus* spp.) constituted most of the centrarchid biomass, while abundant sunfishes (*Lepomis* spp.), including many young-of-the-year, contributed much less. The sunfishes feed on small invertebrates and on some small fishes, at a trophic level whose lower end overlaps that of catostomids. The larger bass are near the top of the food chain, feeding on aquatic vertebrates and larger crustaceans (Scott and Crossman, 1973).

Bowfins, eels, and pickerel occupy trophic levels similar to those of centrarchids (Scott and Crossman, 1973). Together these 3 fishes contributed approximately the same amount to the fish biomass as did the centrarchids.

The community organization in the upper Escambia River demonstrates the contentions of Elton (1946) and Larkin (1956) that "breadth rather than height in the pyramid of a food chain" characterizes freshwater community organization. The highest (pickerel, bowfin, and bass) and lowest catostomids) trophic levels among resident fishes are only a step and a half removed from each other. The dominant catostomids probably contribute little to the next level in the food chain. Most catostomids quickly attain a size equal to or greater than most of the piscivorous fishes, and only young catostomids are subject to extensive predation.

The seasonal influx of euryhaline fishes does not alter the community structure drastically. The gars feed at the same level as bass, pickerel and bowfin. Mullet and shad are primary consumers and detritivores, seasonally occupying the lowest trophic levels in the fish community, increasing by half a level the height of the pyramid of the food chain.

STREAM ORDER—Stream order (Kuehne, 1970) was related to variations in 2 attributes of fish populations examined in this study: seasonality of longnose gar and quillback abundance. The Escambia and Choctawhatchee rivers are fifth and sixth order streams, respectively, but very similar in flow and drainage area. The Apalachicola River is a seventh order stream, and is considerably larger than the other 2 streams (Table 1).

The longnose gar occurred every month except November in the Apalachicola, while in the Escambia and Choctawhatchee it was absent during a longer period in the fall. The longest absence of longnose gar occurred in the Escambia, the lowest order stream of the 3 studied.

Quillback catch rate was highest in the Apalachicola River and lowest in the Escambia. The catch rate for the closely-related highfin carpsucker also followed stream order in the 2 streams where it occurred: it was higher in the Choctawhatchee than in the Escambia.

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Biological Sciences

HYDROLOGY—PLANT COMMUNITY RELATIONSHIPS IN THE OKEFENOKEE SWAMP

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Abstract: *We monitored 7 shallow wells along a transect crossing all of the major habitats in the Okefenokee Swamp and measured water levels, hydroperiods, and water table gradients. Although differences in ground surface elevations between habitats are minor within the swamp, hydroperiods varied from 246-346 da during 1977-78. Extrapolation from nearby staff gauge records indicates that marsh, shrub, and cypress communities were dry for periods of a month or more during 27 of the 36 yr of record, but waterlily communities were without surface water for a month or more only during 16 yr. Water table gradients suggest that ground water flows into the swamp from the surrounding uplands except during droughts, when the flow is reversed.*

Because the composition of plant communities is largely a function of past and present environmental conditions, the relationships between specific site conditions and the occurrence of certain species or plant communities has been studied extensively. In wetland communities, a number of factors including hydrological and chemical conditions, soil types, fire history, and successional patterns (time) have been examined. Information derived from such studies is enabling land managers to develop programs to mitigate or reverse human impacts on wetlands.

Wetlands by definition exist because they are periodically inundated. Thus, hydrological factors relevant to inundation are obviously of prime importance in determining their location and composition. Recent studies have correlated the distribution of particular plant species or communities with specific frequencies of flooding or periods of inundation. (Franz and Bazzaz, 1977; Pesnell and Brown, 1977; Duever et al., 1975).

We found that hydroperiod was the fundamental factor determining distribution of major plant communities at Corkscrew Swamp Sanctuary in southwest Florida (Duever et al., 1975). Hydroperiod appeared to exert direct control by eliminating those species intolerant of extended inundation and indirect control by influencing frequency of severe fires. Within major habitat types, degree of structual development and/or species composition was affected by other modifying factors, such as depth of organic soil, type of mineral substrate, proximity of seed sources, nutrient availability, and history of disturbance.

The significance of fire to the distribution of Okefenokee plant communities had been documented (Cypert, 1973; Cohen, 1974), but the relationship of hydroperiod to major community types was unknown. Although we suspected there might be more subtle hydroperiod contrasts differentiating habitats in the Okefenokee because water levels fluctuate less there than at Corkscrew, we believed that the significance of hydroperiod at ecologically similar Corkscrew Swamp warranted examination of this parameter's influence.

While the data in this paper must be considered preliminary because of the small number of sampling stations and the short period of record, they do provide some valuable new insights on an important aspect of Okefenokee Swamp ecology.

Methods—In June 1978 we installed 7 water level monitoring wells in representative habitats along the Swamp Walk boardwalk which extends from Chesser Island to Seagrove Lake near Camp Cornelia. These are shallow wells with their bases set approximately 0.5 m into the sand below the peat, except for the one in the pine habitat, which is set approximately 2 m below ground. The wells were driven by hand and the 2 open-ended ones (without sand points) were cleared with a pitcher pump. All were pumped for several hours to establish an acceptable interchange with the surrounding ground water. Elevations at the top of each well and every 10 m along the boardwalk were surveyed, the distribution of habitats was noted, and a probe rod was used to measure peat depths. Water levels inside and outside of each well were measured approximately monthly from June 1977-April 1978.

Site descriptions—The pine habitat was a relatively dense stand of trees and shrubs growing on a deep sand substrate. Slash pine *(Pinus elliotti)* up to 15 m high dominated, but vines, shrubs, and hardwood saplings were invading rapidly. Ferns were the primary understory components.

The cypress habitat was or had been dominated by cypress (*Taxodium distichum*) up to about 45 cm dbh and 30 m high. Cypress sites 1 and 2 had been severely burned during the 1954-55 fire, which killed or heavily damaged most of the larger trees and eliminated virtually all the subcanopy components. At both of these sites, the large cypress now form a very open canopy over an extremely dense 4-6 m tall thicket of vines, shrubs, and young hardwoods. There are a few emergent saplings up to 10 m tall.

Cypress site 3 did not burn in 1954-55, and the cypress canopy is complete. Beneath this site's hardwood subcanopy is an open understory with scattered ferns.

White waterlily *(Nymphaea odorata)* covered much of the water surface at the waterlily site. Never-wet (*Orontium aquaticum*), yellow-eyed grass (*Xyris smalliana*), and other emergents were also present.

The marsh sites were typically densely vegetated with a variety of grasses and sedges, particularly maidencane (*Panicum hemitomon*) and *Carex hyalinolepis* up to about 1 m tall.

TABLE 1. Site elevation and 1977-1978 hydrological data for the water level monitoring wells along the Swamp Walk boardwalk.

	Pine	Shrub	Cypress 1	Cypress 2	Cypress 3	Marsh	Waterlily
Elevation[a] (m)							
Mean	5.35	4.81	4.75	4.79	4.74	4.72	4.71
Minimum	5.28	4.71	4.65	4.70	4.70	4.64	4.69
Maximum	5.47	4.90	4.82	4.87	4.78	4.78	4.72
Sample size	4	17	10	16	11	4	4
Water Level[b] (m)							
Minimum	4.49	4.66	4.62	4.69	4.64	4.66	4.70
Maximum	5.27	5.04	5.03	5.05	5.04	5.03	5.07
Hydroperiod[b]	0	212	218	216	219	229	257
Hydroperiod[c]	0	246	259	260	266	280	346

[a] Average for habitat (relative to benchmark we arbitrarily established near end of boardwalk).
[b] For period 29 June 1977-1 April 1978.
[c] Calculated for period 1 April 1977-31 March 1978.

The shrub habitat was a 3-4 m tall thicket of greenbriar *(Smilax* sp.) vines, fetterbush *(Lyonia lucida)*, titi *(Cyrilla racemiflora)*, and other shrubs, and saplings primarily loblolly bay (*Gordonia lasianthus*). There were also scattered 6-8 m high emergent saplings and some open areas dominated by dense grasses and sedges. This site appeared to be a transition zone between grass-sedge marsh and burned cypress.

Except for the pine habitat, all the sites had more than 2 m of peat overlaying a sandy substrate. Sphagnum formed a dense ground cover on the shrub and cypress sites.

RESULTS AND DISCUSSION—Elevations in the pine-dominated habitat bordering the swamp were at least 0.5 m higher than those of the swamp habitats (Table 1), although there was a rather indistinct transition between them. Among the swamp habitats, elevational differences were less distinct: only a few centimeters separated the means and the within-habitat variability considerably overlapped the between-habitat differences.

Although the mean differences in swamp habitat elevations are small, they result in substantial differences in a site's hydroperiod (Table 1). We calculated approximate annual hydroperiods for 1, April 1977 to 1, April 1978, by correlating data from our wells with records from the staff gauge at Camp Cornelia. Three cypress sites had hydroperiods of 259-266 da, a shrub

TABLE 2. Number of years (1941-1976) well sites along the boardwalk would have had no standing water for 1-12 months.

Months Without Standing Water	Marsh, Shrub Cypress	Waterlily
1	3	2
2	2	3
3	2	2
4	3	2
5	4	1
6	3	1
7	2	–
8	2	4
9	–	1
10	2	–
11	1	–
12	3	–
No. of years with at least one dry month	27	16

site was inundated for 247 da, and a marsh site for 280 da. The pine site was dry all year, while the waterlily site had a hydroperiod of 346 da. These data show that while there are probably real, although minor, differences in the hydroperiods of marsh, shrub, and cypress habitats, they are basically successional stages on similar sites. This is corroborated by the results of our studies of successional patterns on floating peat masses (Duever, 1979).

Water level fluctuations in swamp habitats ranged from 36-41 cm during the study period, while the pine site had an annual range of 78 cm. End-of-month water levels at Camp Cornelia indicated a mean annual fluctuation of 51 cm (S.E. ± 3 cm) for the 36 yr period from 1941 to 1976. With the exception of the 1954 value of 118 cm, annual flucuations varied from 23 to 76 cm.

We compared end-of-month water levels at Camp Cornelia with the dates when water levels went below ground in the habitats along the broadwalk and estimated the frequency of years when each habitat was dry for at least one month and the number of months each year when there was no standing water. The marsh, shrub, and cypress sites were dry for at least one month for 27 out of 36 yr of record, but the waterlily site was dry for a month or more during only 16 yr. As would be expected, the three higher habitats were also dry for more months of the year than was the waterlily site (Table 2).

The water table profile along the boardwalk is relatively flat in the swamp habitats (Fig. 1). Minor variations between wells are probably associated with the water surface measurement techniques and small errors in the original survey. Greater variation in the water table surface would be expected when water levels are below ground at some or all sites. Temporary variations could also result from intense local thunderstorms.

The water table in the pine habitat bordering the swamp differs substantially from that in the swamp (Fig. 1). It is depressed during the drought period in early summer. (The July 5 deviation resulted from measurements

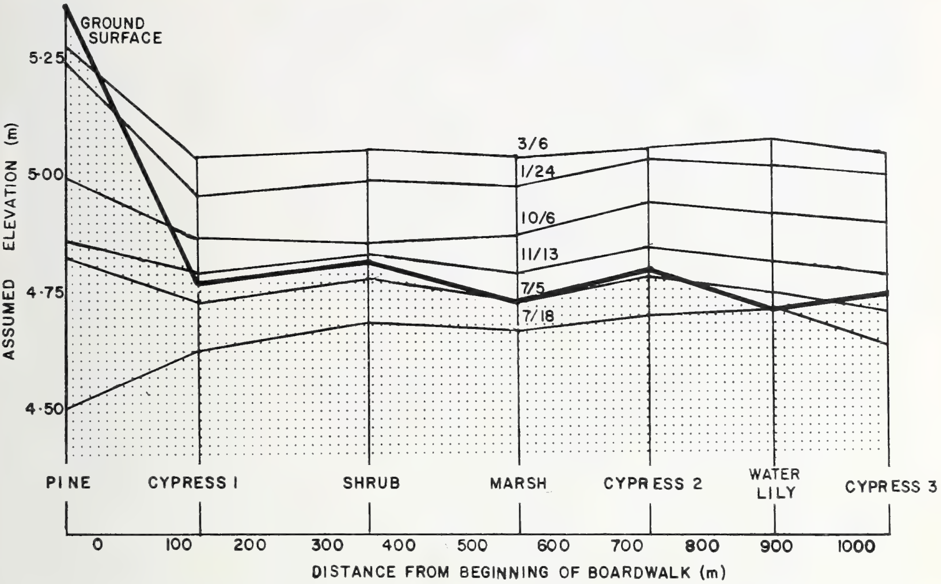

FIG. 1. Selected 1977-78 water level profiles at wells along the Swamp Walk boadwalk.

taken the day after a very heavy rain that temporarily interrupted the drought. The slopes of these profiles suggest that there are normally ground water inflows into the swamp along its periphery, but during extended droughts this flow reverses, and ground water declines more rapidly in the uplands and is replenished by outflows from the swamp.

Hydroperiods are dramatically different in habitats only slightly different in elevation because of (1) the small range of annual water level fluctuation in the Okefenokee Swamp and (2) hydrologic processes associated with a water table that regularly fluctuates above and below the ground surface. Water tables decline faster when below the ground surface than when above it because of the smaller amount of water that can be contained in comparable volumes of a soil profile or water body, respectively. Thus, loss of 1 cm of water from a lake or pond results in a water level decline of 1 cm, while loss of an equivalent amount from a soil profile will cause a water table decline of 5-10 cm or more. Because of this, even though evapotranspiration from a soil profile may result in a smaller total loss of water to the atmosphere than would be associated with evaporation from an open water surface, the water table will still decline more rapidly on the non-inundated site. Differences in water level fluctuations between inundated and non-inundated sites are even more dramatic following periods of heavy precipitation because a subsurface water table tends to rise faster than does an above ground water table, and the resulting down-gradient flows drain water to lower sites, in this case the waterlily prairies. Thus, as has generally been claimed for wetlands on a regional scale, lower areas within the Okefenokee Swamp tend to have more stable water levels. They quickly absorb flood waters and only slowly release them through the year, while the adjacent even slightly higher areas lose water much more rapidly when not inundated resulting in much shorter hydroperiods.

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TWO PLATYHELMINTHS RECOVERED FROM THE GREEN ANOLE, *ANOLIS CAROLINENSIS* VOIGT, COLLECTED IN GEORGIA—*LaRue George Sellers and Amy L. Hertz*, Biology Department, The Savannah Country Day School, P.O. 14256, Savannah, Georgia 31406.

Abstract: *Green anoles,* Anolis carolinensis, *from Chatham and Liberty counties, Georgia, were examined for intestinal platyhelminths. Anoles from Chatham County harbored the trematode* Alloglyptus crenshawi *and the cestode* Oochoristica anolis. *Chatham County, Georgia, is a new locality record for* O. anolis.

The range of the green anole, *Anolis carolinensis* Voigt, extends along the Atlantic and Gulf coastal plains from North Carolina to Florida, westward to central Texas and Oklahoma and northward in the Mississippi Valley to Arkansas and Tennessee. Although it is a very common species throughout its range, few studies have been conducted to determine to what extent it is parasitized. The cestode *Oochoristica anolis* was described by Harwood (1932) from a single specimen taken from the small intestine of *A. carolinensis* collected in the Houston, Texas area. Bennett (1935) described the trematode *Megacustis multispinosus* from the intestinal tract of an *A. carolinensis* collected in the vicinity of Baton Rouge, Louisiana. The digenetic trematode *Alloglyptus crenshawi* was described by Byrd (1950) after examining 30 specimens removed from the small intestine of 1 *A. carolinensis* collected in Baker County, Georgia. Sellers (1971) reported finding 152 adult and 270 immature specimens of the digenetic trematode *Urotrema wardi* from the small intestine of 38 *A. carolinensis* collected in Palm Beach County, Florida, and 2 specimens of the cestode *Oochoristica anolis* from the small intestine of 2 *A. carolinensis* collected in Quachita Parish, Louisiana. Franz and Telford (1972) removed 8 specimens of *A. crenshawi* from the small intestines of 3 *A. carolinensis* collected in Putnam County, Florida and 6 specimens of *U. wardi* from an *A. carolinensis* collected in Gilchrist County, Florida. A report of 15 extraintestinal cestodes, *O. anolis,* fround free in the coelom of 2 male *A. carolinenis* obtained from the Snake Farm, LaPlace, Louisiana, was made by Carter and Etges (1973). We report 2 species of platyhelminths recovered from the intestinal tracts of *A. carolinensis.*

During July 1977 through April 1979 the gastro-intestinal tracts of approximately 118 *A. carolinensis* collected from Chatham and Liberty counties, Georgia, were examined for the presence of helminths. One cestode and 1 trematode species were recovered from the small intestines of 2 lizards. All platyhelminths were fixed with alcohol-formol-acetic fixative. Cestodes were first relaxed in cold tap water; trematodes were extended with slight coverslip pressure. Worms were stained with Harris' hematoxylin and mounted in xylene Kleermount medium. The lizards harboring the helminths were collected by hand in the leaf litter of an oak thicket containing several streams and temporary pools of water. Because of the few reports on intestinal helminths of *A. carolinensis* it seemed desirable to publish these results.

Two specimens of the digenetic trematode *Alloglyptus crenshawi* were recovered from the small intestine of an *A. carolinensis* collected in Chatham County, Georgia on 1 February 1978. Measurements and morphology of these specimens correspond with those given in the original description by Byrd (1950). A specimen of this trematode was deposited in the U.S.N.M. Helm. Coll., Beltsville, Maryland (No. 75747).

Nine specimens of the cestode *Oochoristica anolis* were removed from the small intestine of 1 *A. carolinensis* collected in Chatham County, Georgia on 24 October 1978. The worms were all active adults and were located in the same general vicinity of the small intestine. Measurements and morphology of these specimens correspond with those given in the original description by Harwood (1932). To our knowledge this is the third report of *O. anolis* since its description by Harwood (1932). This find significantly extends the known geographic range of this cestode making Chatham County, Georgia, a new locality record for *O. anolis.* A specimen of this cestode was deposited in the U.S.N.M. Helm. Coll., Beltsville, Maryland (No. 75748).

Acknowledgments—We thank Barry Evans and Grady Knight for field assistance during this study.

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Biological Sciences

DISTRIBUTION, ABUNDANCE AND SIZE OF *CORBICULA MANILENSIS* (PHILIPPI) IN A SPRING-FED CENTRAL FLORIDA STREAM

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Abstract: *Asiatic clams* (Corbicula manilensis Philippi) *were sampled at 12 stations along a 16 km reach of the Wekiva River, Florida at 3-mo intervals between August 1976 and June 1977. The abundance of the clams range from 4-1,210 per m*^{2}*. The greatest numbers of clams were found where the bottom sediments were comprised of clean, fine sand; lowest numbers were found in silty, organic sediments near the headwaters. Seasonally, larger clams were collected in December 1976 (mean shell length = 13.7 mm), whereas small clams were most evident in March 1977 (mean shell length = 13.1 mm).*

The Asiatic clam (*Corbicula manilensis* Philippi) is exotic; its introduction into the United States occurred in the Columbia River estuary, Washington, in 1938 (Dundee and Harmon, 1963). After its introduction, its dispersal throughout the continental United States was rapid; by 1940 *Cor-*

bicula were reported in the Sacramento and San Jaoquin River systems and by the early 1950s the clam was found in irrigation canals in southern California (Dundee and Dundee, 1958). *Corbicula* were taken from the Tennessee River in 1959 (Sinclair and Ingram, 1961); it was found in several Louisiana gulf coast streams and in the Mobile River in 1960 (Keup et al., 1963) and in 1963 it was established in the upper reaches of the Green and Cumberland rivers (Sinclair, 1964). *Corbicula* were first reported in the Southern Atlantic Slope drainage in 1970 when specimens were collected from the Ocumulgee River, Georgia (Sickel, 1973). In 1972, collections of the clam were made in the Savannah River (Fuller and Powell, 1973). The Asiatic clam was first reported in Florida in 1960 in the Escambia River (northwest Florida). By the mid 1960s the clam had become established in the Withlacoochee River in Levy County (Schneider, 1967). By 1969, the species was found in the Lake Okeechobee system, thus completing its spread down the Florida peninsula (Clench, 1970).

While the clam was initially identified as *Corbicula fluminea*, it is now assumed to be *C. manilensis* due to major differences in reproduction between the 2 species. *C. fluminea* are dioecious and nonincubatory, while *C. manilensis* are monoecious and incubate their eggs in marsupia. *C. manilensis* is considered the only species within the United States (Sinclair and Isom, 1963).

The unique reproduction of *Corbicula* has facilitated its rapid spread within the United States. The veliger (length approximately 0.2 mm) is discharged through the exhalent siphon into the surrounding water. Daily average reproduction has been observed as high as 387 veligers per adult. The free-living veligers are benthic as the velum is specialized for feeding rather than swimming. In flowing waters, veligers which become planktonic move downstream and may enter irrigation systems, condensers and pipes where they settle and become attached by means of byssal threads. The species may become a nuisance in power plants and irrigation systems. *Corbicula* become sexually mature during their first year and at a length of approximately 6 mm (Sinclair and Isom, 1963).

Due to the rapid population growth and competition for food and space, *Corbicula* are known to replace native species of bivalves (Garder et al., 1976). Smaller bivalves appear to be more affected than larger ones (Sickel, 1973). The composition of the sediment has been suggested as the most important factor affecting the distribution and abundance of the species. *Corbicula* may inhabit coarse and fine gravel, black clay, shifting sand bars, rock and rubble, and firm sand, but usually it is found in greatest abundance in sandy substrates (Sickel, 1973; Fuller and Powell, 1973). The clam probably is found associated with sandy substrates because dissolved oxygen concentrations are higher near that type of substrate. *Corbicula* may tolerate low dissolved oxygen concentrations for short periods, but prolonged exposure to dissolved oxygen levels near 0 ppm can be fatal (Sinclair and Isom, 1963).

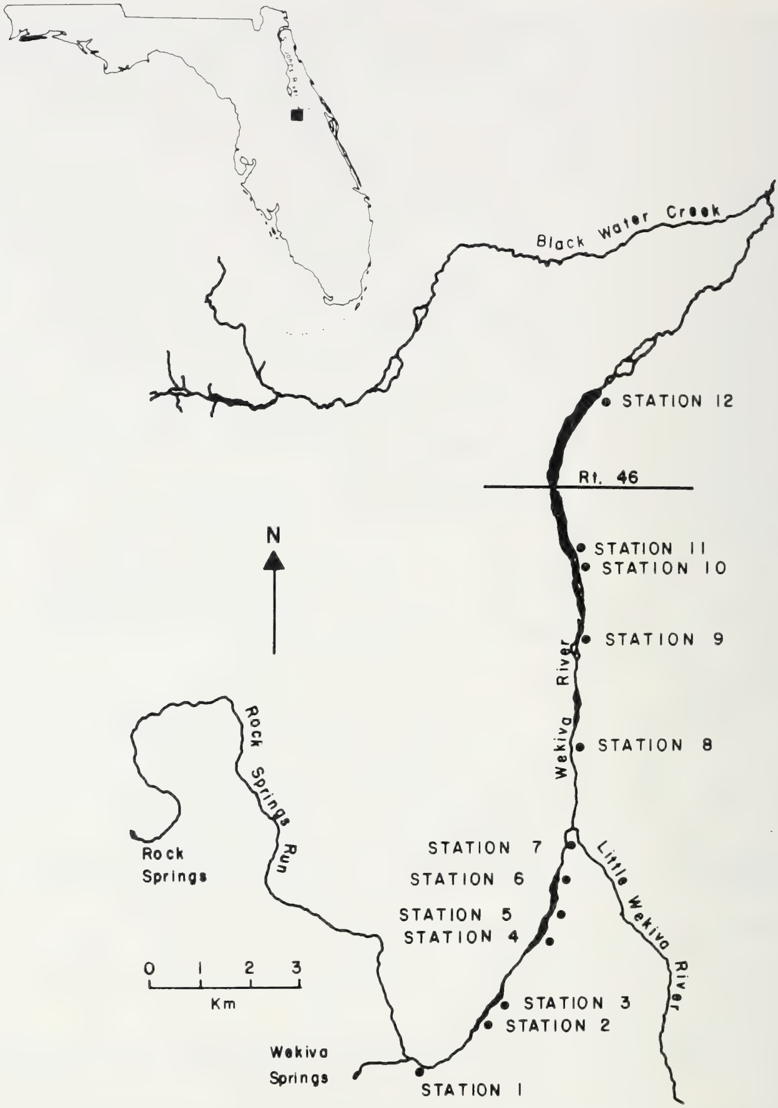

Fig. 1. Wekiva River, Florida with sampling stations.

We discuss the distribution, abundance and size of *Corbicula manilensis* Philippi in the Wekiva River and relate its abundance to the physicochemical features of the river.

Description of the Study area—The Wekiva River is a spring-fed stream with its source (Wekiva Springs) located about 5 km east and 4 km north of Apopka, Florida, in northwest Orange County, 28° 42′ N; 81° 27″W. The river flows north-northeast along a 26 km course and enters the St. Johns River 10 km northwest of Sanford, Florida. The average width of the river is 77 m, but varies between 32 and 200 m. The Little Wekiva River, Rock Springs Run and Black Water Creek are its major tributaries (Fig. 1). The Wekiva Swamp and Seminole Swamp comprise most of the 490 km^2 watershed. The river, with an elevation decrease of approximately 1 m per 5 km, has had mean daily discharge from 2.97 to 58.3 m^3/sec since 1939. Mean daily discharge during this study was 8.16 m^3/sec (U.S. Geol. Sur., 1977).

Numerous small islands divert the flow as the river passes through the Wekiva Swamp, the region between the inflow from the Wekiva Springs Run and the Little Wekiva river (Fig. 1). The deposition of silt and organic debris is enhanced in this region of the river by low current velocity caused by the islands and submersed aquatic vegetation. While *Vallisneria americana* (eelgrass) and *Egeria densa* (Brazinian elodea) are present in this reach, *Vallisneria americana* is more common. *Eichhornia crassipes* (waterhyacinth), an exotic floating macrophyte, is an important contributor of organic siltation in the river. The Wekiva River is widest and most shallow about 10 km downstream from Wekiva Springs (Fig. 1). Along this reach, the flood plain becomes considerably narrowed as the elevation of the surrounding topography becomes 5 to 10 m higher. It is in this reach that the sediment changes from organic silt to sand and *Egeria densa* becomes the dominant aquatic macrophyte.

METHODS AND MATERIALS—Twelve permanent stations were sampled along a 16 km stretch of the Wekiva River (Fig. 1). The stations were selected with a randomized scheme at the beginning of the study to eliminate bias in their initial placement. Three sites per station (near the bank and in the center of the stream) were sampled trimonthly from August 1976 to June 1977.

Physicochemical measurements were taken concurrently at each site. These measurements included surface and bottom water temperature, current velocity with a subsurface float (Hynes, 1972), turbidity (American Public Health Association, 1971), alkalinity (APHA, 1971), and hydrogen-ion concentration. Sediment was collected with a plexiglass tube (dia - 5 cm). An 8 cm core sample was oven dried at 105 C for 48 hr and weighed to the nearest 0.001 g. The dried sediment was ignited in an ash furnace at 600 C for a period of 5 hr to determine the percentage organic content of the sediment by weight. Sediment samples were collected at each sampling site to determine particle size in June 1977. These samples were wet seived through 6 U.S. standard screens (0.11 - 2.5 mm mesh); the sediment that remained in each screen was dried at 105 C for 48 hr. Particle size was expressed as a percentage of the dry weight of the sediment sample.

Corbicula were sampled with a Surber sampler (0.093m^2) (Surber, 1937) by removing 8 cm of sediment. Three samples were taken from each site for a total of 9 sampling stations. The clams were washed in a #30 mesh seive and preserved in 20% formalin. The clams were enumerated and measured for length to the nearest 0.1 mm with vernier calipers.

RESULTS AND DISCUSSION—Relative low numbers of *Corbicula* were

TABLE 1. Annual mean values for the abundance of *Corbicula*, the % organic content and particle size of sediment, and water depth in the Wekiva River by station, August 1976-June 1977. Particle size for sediment was classified as fine (0.11-0.42 mm dia), medium (0.43-1.43 mm dia), and coarse (1.44-2.5 mm dia). The 95% confidence limit is given in parenthesis.

Station	*Corbicula* Abundance (#/m^2)		% Organic Matter of Sediment	Water Depth (m)	Sediment Particle Size (%)		
					Fine	Medium	Coarse
1	14	(16)	26.5	1.15	51.8	36.0	13.3
2	61	(46)	17.6	0.96	65.5	11.6	22.9
3	76	(53)	6.9	0.91	60.2	29.1	4.5
4	0	(0)	14.7	1.03	68.2	21.5	7.9
5	0	(0)	11.8	0.95	69.7	17.5	6.6
6	0	(0)	24.6	1.08	61.9	12.7	25.4
7	3	(3)	20.8	1.34	60.4	18.1	21.5
8	28	(38)	24.3	1.18	61.0	23.5	27.8
9	123	(148)	12.9	0.76	83.3	8.7	8.1
10	370	(238)	5.3	0.63	80.1	17.5	2.6
11	1040	(1031)	5.0	0.58	87.7	12.3	4.0
12	65	(80)	3.8	0.61	82.7	12.9	4.3

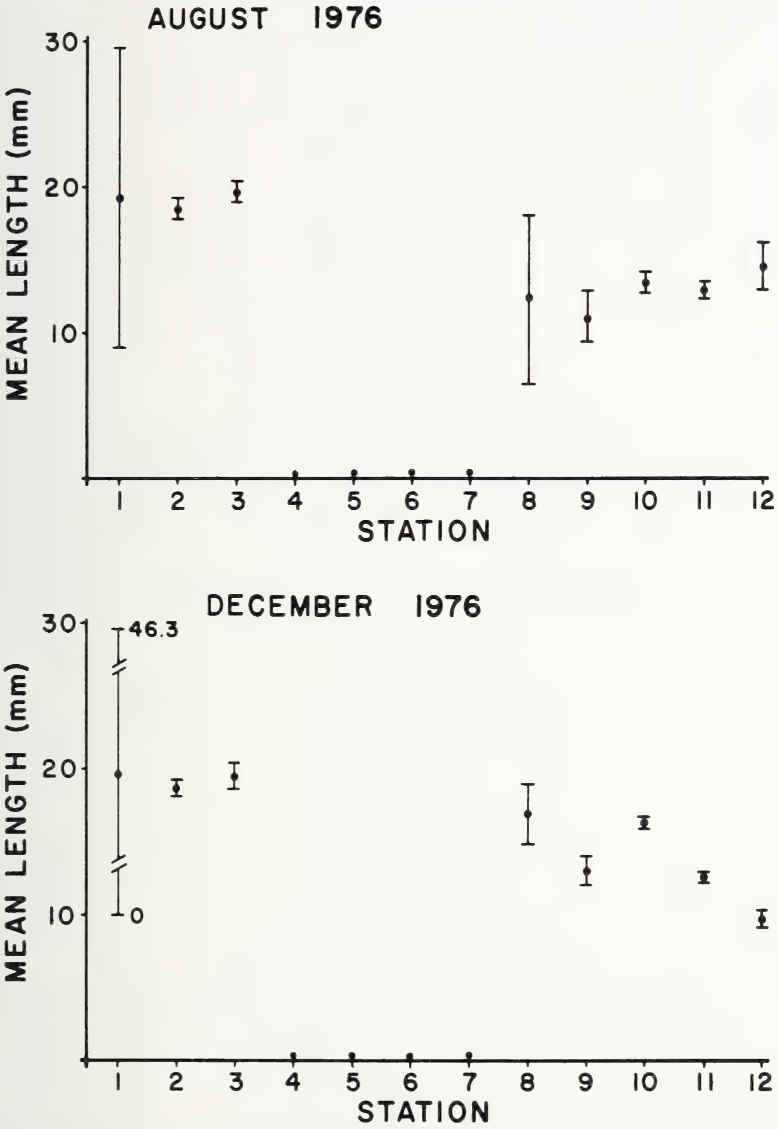

FIG. 2. Mean shell length of *Corbicula* collected during August and December 1976 at 12 sampling stations in the Wekiva River. The vertical lines indicate the 95% confidence limit for the mean.

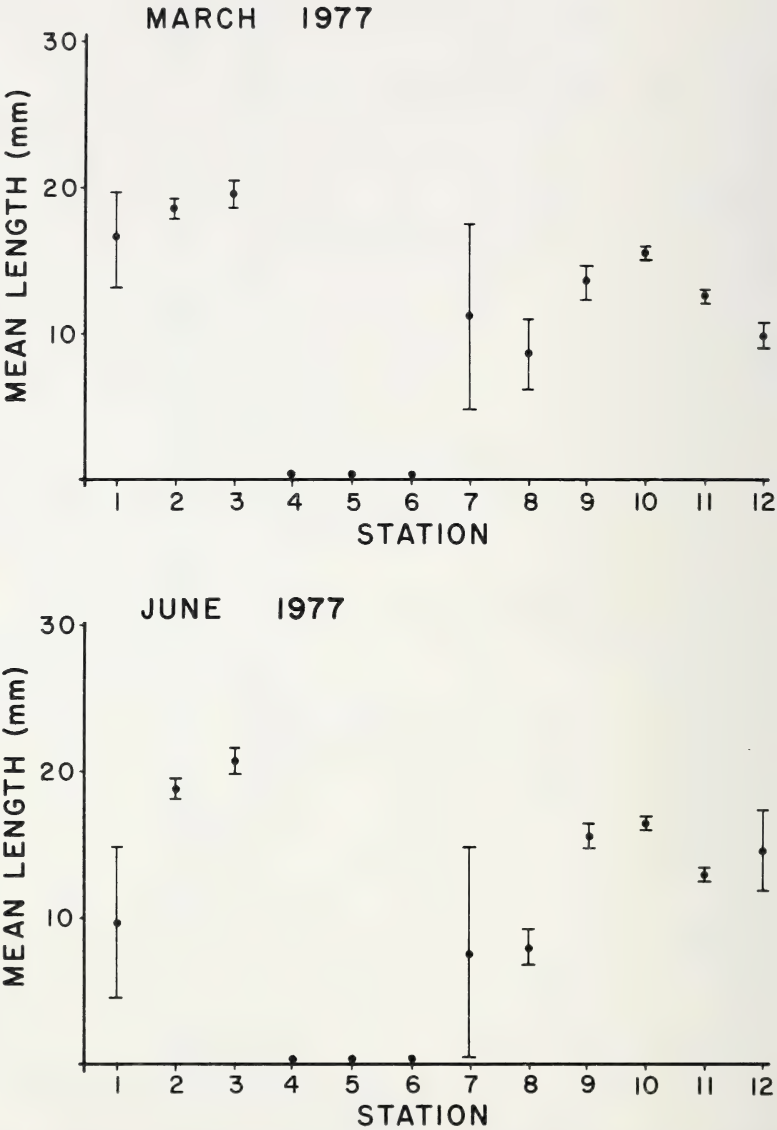

FIG. 3. Mean shell length of *Corbicula* collected during March and June 1977 at 12 sampling stations in the Wekiva River. The vertical lines indicate the 95% confidence limit for the mean.

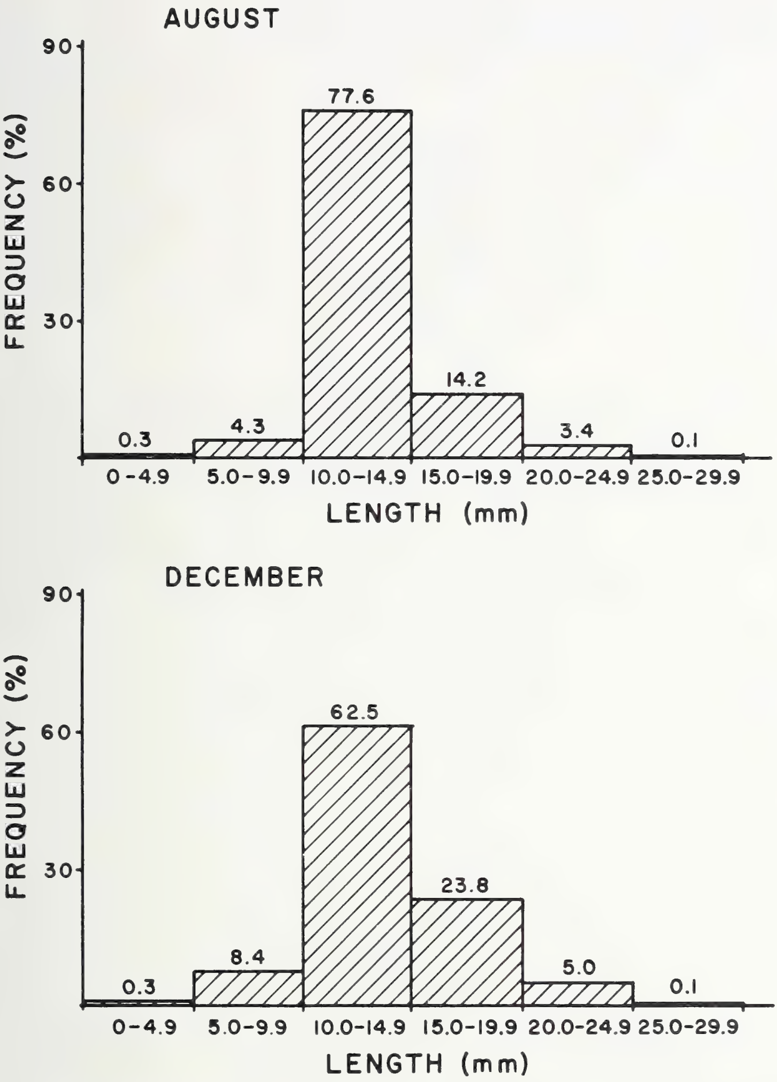

FIG. 4. Size frequency for shell length of *Corbicula* collected during August and December 1976 in the Wekiva River.

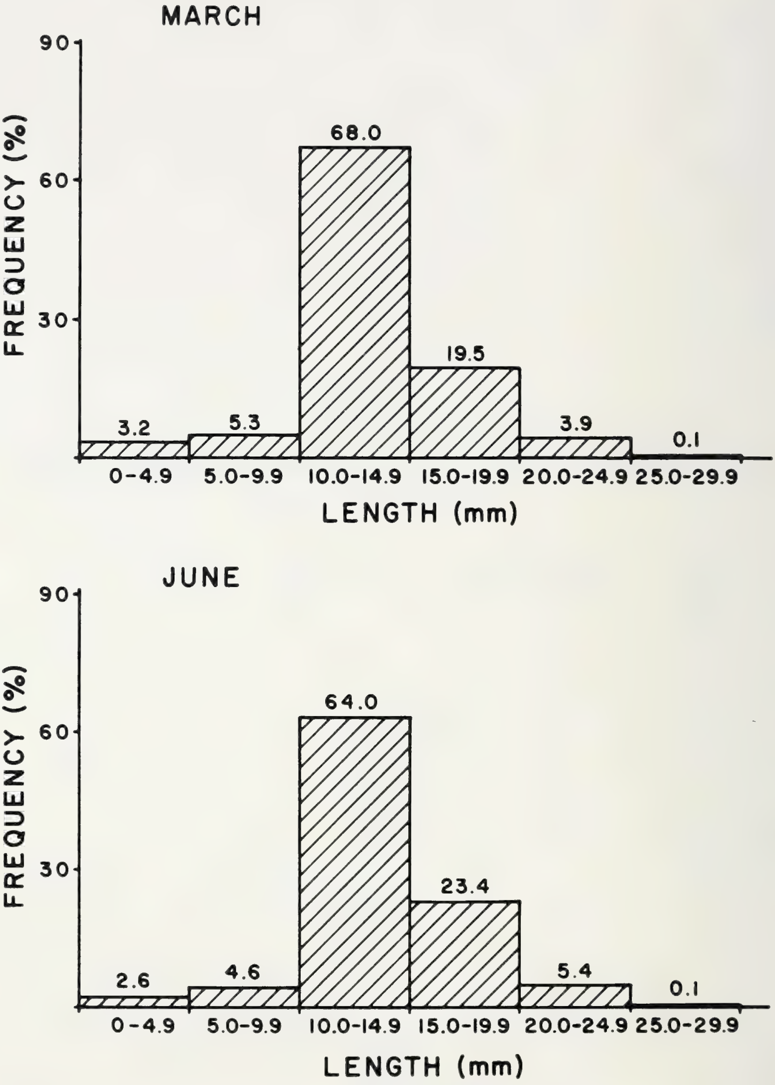

FIG. 5. Size frequency for shell length of *Corbicula* collected during March and June 1977 in the Wekiva River.

TABLE 2. Monthly means for *Corbicula* abundance and size for various physicochemical measurements taken in the Wekiva River, August 1976-June 1977. The 95% confidence limit is given in parenthesis.

	August	December	March	June
Corbicula abundance (#/m^2)	231 (154)	189 (98)	207 (143)	219 (156)
Corbicula shell length (mm)	13.4	13.7	13.1	13.6
Organic content of sediment by weight (%)	11.2	12.7	13.8	20.4
Water temperature (C)	25.0	20.0	19.5	24.3
pH	7.2	7.3	7.7	7.7
Total alkalinity (mg/l $CaCO_3$)	96.5	96.8	98.9	102.0
Turbidity (Pt-Co units)	0.0	0.0	0.0	0.0
Flow rate (cm/sec)	15.0	17.3	18.3	16.8
Water depth (m)	1.03	0.89	0.95	0.85

Mean pH was calculated using the antilog of the hydrogen-ion concentration.

found within the Wekiva River. Of the 12 stations sampled, abundance greater than 100 individuals/m^2 was found at 3 stations (station 9, 10 and 11), with 1 station (station 11) having greater than 1000 individuals/m^2 (Table 1). Clams were not found at station 4, 5 and 6. Generally, the number of *Corbicula* within the Wekiva River was lowest near the headwaters where sediments were comprised of fine silt with an organic content greater than 20% by weight (Table 1). In this region of the river, few clams were encountered along the banks or around beds of submersed vegetation where low current velocity resulted in the deposition of fine silts and organic debris. The loosely-packed silts and very fine organic debris associated with stations 4, 5 and 6 probably accounted for the lack of *Corbicula* at those stations (Fig. 1). *Corbicula* were most abundant at the downstream stations in sediment comprised of fine sands (0.11-0.43 mm dia) and where the sediment contained less than 6% organic matter by weight (Table 1). Water depth at the downstream stations was generally less than 0.75 m, while water depth approached or exceeded 1.0 m at upstream stations. Flow did not differ significantly between upstream and downstream, although flow was severely reduced near and among beds of *Egeria densa* (downstream) and *Vallisneria americana* (upstream). It is believed that *Egeria densa* may have entraped clam veliger downstream, as larger numbers of clams were taken in beds of this plant than in sediments free of vegetation. While *Corbicula* abundance was higher downstream where water depth was lower, it is felt that sediment type and particle size were responsible for greater numbers of clams downstream. Only slight differences were seen between upstream and downstream values for pH, total alkalinity, flow rate, and water temperature. Turbidity was not detected in the river except after sediment was distrubed by motor boat.

Monthly mean *Corbicula* abundance ranged from 189-231 individuals/m^2 (Table 2). While fewer numbers of clams were taken in December 1976, generally the clams tended to be larger (Table 2). Throughout the study, larger clams were taken at upstream stations (Figs. 2 and 3); it is assumed that these clams were the brood source for clam populations downstream. The mean shell length of clams taken from stations 1-3 generally ranged from 15-20 mm, while the mean shell length for clams taken from stations 8-12 generally ranged from 10-15 mm. The dominant size of *Corbicula* in the river was between 10.0 and 14.9 mm (Figs. 4 and 5). Little variation was seen in the size frequency curves between seasons. Few clams (0.1%) were found to have shell lengths greater than 25 mm. Because individual clams with shell lengths greater than 6.0 mm are regarded as sexually mature (Sinclair and Isom, 1963; Gardner et al., 1976), one can assume that nearly 90% of the *Corbicula* population in the Wekiva River during this study were sexually mature (Figs. 4 and 5).

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BONE ANOMALIES IN THE SHELL OF *GOPHERUS POLYPHEMUS*

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ABSTRACT: *Shells of adult* Gopherus polyphemus *and* Gopherus berlandieri *were examined to determine the frequency and distribution of bone anomalies. A broad spectrum of anomalies was present in both species; supernumerary bones in the neural region of the carapace occurred with regularity and had opposite correlations with average size in males and females.*

SHELL anomalies in turtles have been recognized and documented for the past 8 decades (Parker, 1901; Coker, 1905a, b; Gadow, 1905; Newman, 1906; Berry, 1935; Lynn, 1937; Hildebrand, 1938; Lynn and Ullrich, 1950; Zangerl and Johnson, 1957; Auffenberg, 1976). However, the formulation of definitive theories with which to synthesize what is now a substantial amount of data has yet to be realized. Consequently no hypothesis was tested during this study. Rather, the data are baseline in nature and offer quantification on the placement and frequency of shell anomalies in *G. polyphemus*. Additionally, as an indicator of shell anomaly occurrence on a generic level, equivalent data were recorded for a restricted sample of *G. berlandieri*. Illustrations and nomenclature of standardized carapaceal and plastral elements have been included for reference (Fig. 1).

METHODS—The selection of *G. polyphemus* for the purpose of studying shell anomalies was based on the recognition of a relatively high frequency of aberrant shell conditions in this species (Auffenberg, pers. com.).

Specimens used in this study (*G. polyphemus* = 161, *G. berlandieri* = 40) are in the Herpetology and Zooarchaeology Collections of the Florida State Museum. They are considered a random sample collected over an extended period of time. Only Florida specimens of *G. polyphemus* from east of the Apalachicola River were used in the study.

The sample was limited to specimens which met the following criteria: a) minimum carapace length of 150 mm (minimum standard length established to assure a reasonably mature sample wherein shell fontanels were closed or newly closed and potential anomalies already realized; b) carapace sufficiently intact to allow accurate examination and measurement; c) no evidence of injury during ontogeny which could potentially obliterate or generate anomalies; and d) no carapaceal elements lost in butchering process in the case of salvaged specimens.

Individuals missing plastra (25%) as a result of butchering were not excluded from the sample because observation shows that nearly all anomalies in this species occur in the carapace.

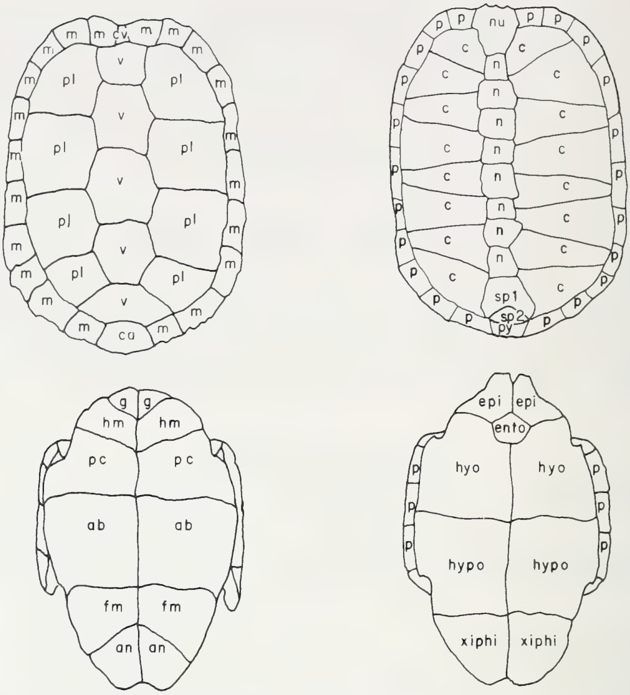


FIG. 1. Standardized nomenclature of tortoise scute and bone elements. Abbreviations: cv, cervical; m, marginal; pl, pleural; v, vertebral; ca, caudal; g, gular; hm, humeral; pc, pectoral; ab, abdominal; fm, femoral; an, anal; nu, nuchal; n, neural; c, costal; p, peripheral; sp, suprapygal; py, pygal; epi, epiplastron; hyo, hyoplastron; hypo, hypoplastron; ento, entoplastron; xiphi, xiphiplastron.

All data were recorded on a peripheral punch card system. One hundred and fourteen categories were coded and recorded for each specimen. These categories included all bone and scute elements present on the tortoise carapace and plastron, male/female, addition/deletion, injury and evidence of butchering. Additional information recorded for each specimen was collection location, carapace and plastron measurements, and a drawing of any anomalous manifestation.

Gopherus polyphemus—The results from material studied show that: 1) anomalies in the form of supernumerary bones are extremely frequent (63.2%), 2) carapaceal bone anomalies occur in 61% of all specimens, 3) bone aberrations occur predominantly in the posterior neural region (92% of all singular anomalies are located in this region), 4) anomalies occur in only 1.8% of all plastra examined, 5) scute anomalies are rare (1.2% of the entire sample), 6) bone deletions occur at low frequencies (2.4%). Unfortunately, the paucity of published data on bone anomalies within other Testudinata genera restrict interpretation to the data presented herein.

Supernumerary Bones: The area in which supernumerary elements occur most often (50% of all specimens examined) is between the seventh and eighth neural bones of the carapace (Table 1). This phenomenon has a range of manifestations (Fig. 2) which vary from a single, symmetrical extra bone to asymmetrical clusters of small supernumerary bones. The presence of an anomalous bone(s) between the seventh and eighth neurals constitutes 84% of all singular anomalies and 83% of all multiple anomalies.

Chi-square test results indicate no significant difference in the occurrence of this anomaly between male and female individuals, so the trait does not appear to be related to sex ($\times^2 = .29$, df = N-1, P (.29) > .05).

There is, however, a significant difference in the average carapace length of individuals with and without the supernumerary neural bones. As indicated in Fig. 3, male specimens with this condition (N = 22) had a mean carapace length of 250 mm; those without (N = 21) averaged 231.1 mm. This difference in average carapace length among males with and without the presence of anomalies was significant at the .05 level (t = 2.23, df = 80).

TABLE 1. Distribution of bone anomalies in *Gopherus polyphemus*.

	No Anomalies	Singular	Multiple	7/8 Neurals
Male				
No. of Individuals	21	27	11	22
Mean Carapace Length (mm)	231.091	248.289	240.7	250.001
Female				
No. of Individuals	23	28	6	23
Mean Carapace Length (mm)	255.191	242.156	257.971	237.717
Unsexed				
No. of Individuals	16	23	6	18
Mean Carapace Length (mm)	246.681	248.304	254.5	246.567

7/8 anomaly figure included within appropriate singular or multiple anomaly category.

Females displayed an inverse relation between the presence of supernumerary neural bones and size. Female specimens with the anomalous condition (N = 23) had a mean carapace length of 237.7 mm; those without (N = 23) had a mean carapace length of 255.2. Those with multiple anomalies (N = 7) had a mean carapace length of 258.0 mm. Thus, the presence of anomalous bones between the seventh and eighth neurals suggests adverse effects on the potential carapace length of females (92.2% of maximum growth obtained). As previously mentioned, however, among females there is no strong selection against this trait, as it occurred in 57% of the female specimens examined.

Seemingly analogous to this anomaly is the second most frequent aberrancy: the presence of an additional bone between the eighth neural and the first suprapygal. Although this anomaly occurs less frequently, being present in 44% of all shells with multiple anomalies and 8% of all with singular anomalies, it too seems to be a manifestation of the overall genetic variability of the supra-pelvic area of the carapace. This assumption is based on the

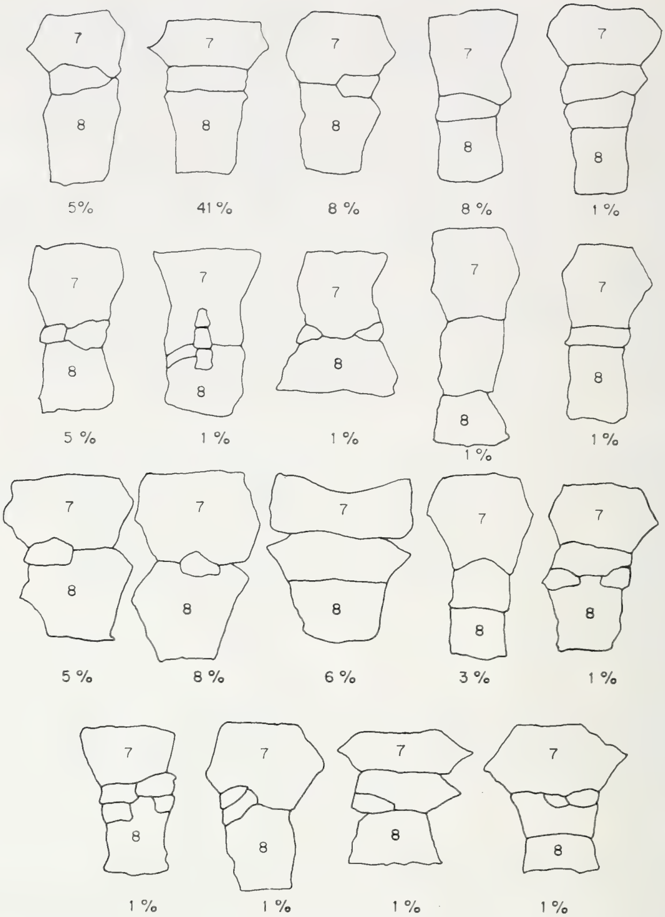


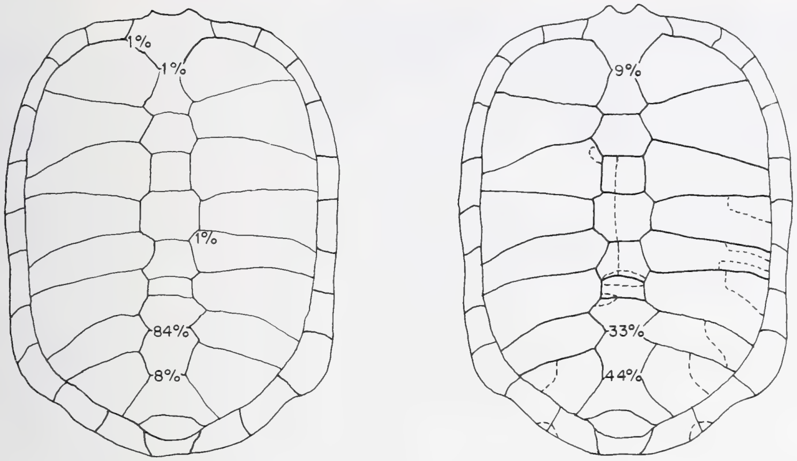
FIG. 2. Various anomaly configurations occurring between posterior neurals.

relative size and formation of these supernumerary elements, the close proximity of this region of anomaly to that initially discussed, and the equal distribution of this aberrant condition among both sexes.

With the exception of an aberrant bone occurring adjacent to the nuchal bone in 9% of all multiple anomalies (Fig. 3), all other bone aberrancies occurred in a single instance or constituted only 1% of all anomalies.

Plastral anomalies among *G. polyphemus* were extremely rare (1.8% of total sample). When they did occur (2 incidences of a singular supernumerary bone, one incidence of multiple additional bones), it was consistently in the median region of the hyo-hyoplastron suture (see Fig. 1).

Plastral lengths were not affected by the presence of anomalies anywhere on the shell. In comparing the plastra lengths of individuals with anomalies either on the carapace or plastron to those plastra where shell anomalies were absent, no significant difference was found ($t = .05$, $df = 109$, at the



Singular Anomalies Multiple Anomalies

Dotted areas represent a single occurrence in a multiple anomaly situation.

FIG. 3. Distribution of bone anomalies in *Gopherus polyphemus*.

.05 level of significance). On a whole, plastra exhibited minimal variability, in sharp contrast to the carapaces. Unlike the carapace, the plastron is not highly susceptible to aberrancies and maintains relative size stability ($\bar{x}$ plastra length with shell anomalies = 224.4 mm, $\dot{x}$ plastra length without shell anomalies = 223.964 mm).

Bone Deletions: Bone deletions occurred infrequently (2.4%, N = 4) and without regularity; twice in the neural region and once in both the costal and peripheral areas. They represent, initially, one of the most difficult anomalies to detect as they are well compensated for by expansion of adjacent elements.

Scute Anomalies: Scute abnormalities were scarce (1.2% of sample), occurring only twice, once as an irregularly divided vertebral scute and once as a deletion in the marginal region. This deletion corresponded with the exclusion of the underlying peripheral bone which is apparently a common phenomenon and corroborates the findings of Parker (1901), Newman (1906), and Lynn (1937).

Gopherus berlandieri—Within extant species of *Gopherus*, the most morphologically divergent from *G. polyphemus* is *G. berlandieri* (Auffenberg, 1976). Thus, to gain broader insight into shell aberrancies in the genus as a whole, 38 specimens of *G. berlandieri* were examined for anomalies.

Supernumerary bones occurred in 68% of the *G. berlandieri* specimens (cf. 63.2% in *G. polyphemus*). Thirty-four percent of the specimens possessed an extra bone(s) between the seventh and eighth neurals, constituting 77% of all singular aberrancies (Fig. 4). As in *G. polyphemus*, there was a difference in mean carapace length of *G. berlandieri* males with and without supernumerary elements between the seventh and eighth neurals; however,

TABLE 2. Distribution of bone anomalies in *Gopherus berlandieri*.

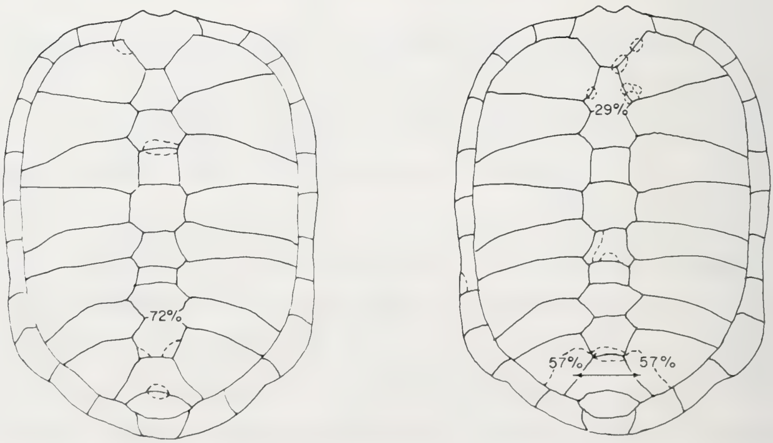
	No Anomalies	Singular	Multiple	7/8 Neurals
Male				
No. of Individuals	8	15	5	12
Mean Carapace Length (mm)	175.862	182.073	184.18	181.592
Female				
No. of Individuals	4	5	2	1
Mean Carapace Length (mm)	163.2	150.867	155.55	169.7

7/8 neural anomaly figure included within singular anomaly figure.

this difference was not significant at the .05 level. Males with the aberrant condition (N = 12) obtained a mean carapace of 181.592 mm, while those without the anomaly (N = 8) reached a mean length of 175.862 mm (Table 2). This is 96% of the potential maximum growth obtainable by males of this species, as demonstrated by 5 specimens with multiple anomalies who attained a mean carapace length of 184.18 mm.

Female *G. berlandieri* showed the same pattern recognized in female *G. polyphemus*, with only one exception. Females without anomalies (N = 4) obtained a greater mean length (163.2 mm) than those with anomalies (N = 7, $\bar{x}$ length = 155.5). Although these data suggest a closely related pattern in females of both *Gopherus* species, the limited sample size of *G. berlandieri* restricts any statistical correlation at this time.

DISCUSSION—The high incidence of bone anomalies in *G. polyphemus* raises the question of what is normal versus anomalous within this species. Although random genetic mutations occur occasionally, regularly patterned bone aberrancies occur in over 50% of the total population sampled. These aberrancies, for reasons unknown, correlate with larger size in males



Singular Anomalies
Multiple Anomalies

Dotted areas represent a single occurrence.

FIG. 4. Distribution of bone anomalies in *Gopherus berlandieri*.

and smaller size in females. Although the distribution of bone anomalies is considerably more varied in *G. berlandieri*, the frequency with which they occur exceeds that found in *G. polyphemus*, suggesting that the genus as a whole may show exaggerated variability of bony carapace elements.

Based on the high ratio of bone aberrancies within this genus, the relative scarcity of scute anomalies was unexpected. This is particularly true in view of Grant's findings (1937) that abnormal scutellation occurred in 10% of the 300 + specimens of *G. agassizii* he examined. However, given the rare occurrence in *G. polyphemus* and G. berlandieri, no pattern of scute variation is evident. However, the repetitive occurrence of certain bone aberrancies warrants further investigation. The following hypotheses are offered as plausible explanations for the occurrence of supernumerary bones in the posterior neural region: 1) a relaxed genetic expression in a nonvital region of the carapace (Auffenberg, pers. comm.), 2) genetic polymorphism, or 3) differentiation in the soft tissue, of which the dermal bone is an outward expression. Atavism, or the reccurrence of characteristics from a fossil form, has also been suggested as the causal factor in some instances of turtle abnormalities (Parker, 1905). However, based on 6 specimens of *Stylemys nebrascensis* [White River Oligocene] examined, this hypothesis does not appear to be valid respecting *Gopherus*.

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TEMPERATURE LIMITATIONS TO THE DISTRIBUTION OF MANGROVE MOSQUITOFISH IN FLORIDA—*Charles D. Getter*, Research Planning Institute, Inc., 925 Gervais Street, Columbia, South Carolina 29201: Baruch Institute of Marine Biology and Coastal Research, University of South Carolina, Columbia, South Carolina 29208.

Abstract: *An extensive survey of southern Florida revealed a limited, coastal distribution of the mangrove mosquitofish* (Gambusia rhizophorae). *However, discovery of the species in collections from Cuban fresh waters indicates that it is not salinity-limited. Laboratory studies determined the low-temperature tolerance of the species to be 17°C (Baumgarten, 1949). The winter, low-temperature isotherm for southern Florida at this temperature intersects all furthest-known points north and west of the species' distribution. Temperature limitations to distribution may be controlled by fertility which, for the mangrove mosquitofish, is known to be correlated with temperature.*

Two intensive studies of the mangrove mosquitofish produced data concerning their temperature tolerances (Baumgarten, 1949) and their life history, including distribution and reproduction (Getter, 1976; 1980). An extensive field survey of southern Florida from 1973 to 1980 included collections and observations of shallow-water ichthyofauna as well as water-quality data from over 500 sites (Getter, 1981). All methodology is described in detail in Baumgarten (1949) and Getter (1981). The observations made during these studies form the basis for this discussion.

Results—Mangrove mosquitofish were found at 3 localities north of Miami. At the Fort Lauderdale locality, the mangrove mosquitofish inhabit a cooling canal which receives heated water from a power plant. This is the northernmost known locality for the species. A large population of the mangrove mosquitofish was found in Cocoplum and at Matheson Hammock on the western shore of Biscayne Bay. They were also found in southern Biscayne Bay, Card Sound, northern Key Largo, and Totten Key.

Mangrove mosquitofish were found at 2 localities in Florida Bay: 4.5 km and 5.5 km west of Key Largo. The latter is now the westernmost known extension of the mangrove mosquitofish into Florida Bay. It lies at Shell Creek, a mangrove-lined channel between Florida Bay and Long Sound. Mangrove mosquitofish were not observed farther west at Trout Creek or at other sheltered mangrove areas west of Shell Creek. Thus, the encroachment of the mangrove mosquitofish into Florida Bay is very limited. These observations are supported by the absence of other researchers' reports on mangrove mosquitofish west of Shell Creek (Kilby and Caldwell, 1955; Tabb and Manning, 1961; Roessler, 1970). Observations of the mangrove mosquitofish at mangrove channels through Boggy Key, Dusenbury Creek, and Shell Creek establish the presence of the species within the boundaries of the Everglades National Park where it was previously unreported (Phillips, 1971). In addition to mainland areas, several outlying islands in Florida Bay were surveyed without locating the species.

The mangrove mosquitofish was found at several localities on Key Largo and in the upper Florida Keys. Only 3 populations were found in the middle keys (between Key Largo and Vaca Key). In the lower keys, mangrove mosquitofish were collected at Bahia Honda Key, Big Pine Key, Little Torch Key, Cudjoe Key, Saddlebunch Key, Sugarloaf Key, Stock Island, and Key West. The Key West collection is the southernmost known location for the mangrove mosquitofish in Florida. No collections were attempted or reported at the Marquesas, which lie 30 km west of Key West, or at Tortugas Islands 100 km west of Key West (Longley and Hildebrand, 1941). Based on this field survey, the Florida distribution of the mangrove mosquitofish is determined to extend from Fort Lauderdale, south along the mainland to Key Largo, through the Florida Keys to Key West.

Outside Florida, the mangrove mosquitofish has been reported at 4 localities in Cuba (Rivas, 1969). Three of these are coastal areas 40-80 km west of Havana. The fourth locality at Mantanzas is in a coastal region 120 km east of Havana. Re-examination of collections made by Rivas in Cuba show populations of a closely related species, *Gambusia punctata*, living together with the mangrove mosquitofish at several localities in Cuban fresh waters (Getter, 1976). These localities constitute new distribution points for the mangrove mosquitofish in Cuba, being within or near the city limits of Havana.

Salinity throughout the Florida range of *G. rhizophorae* was found to be from 13.0 to 53.0 ppt, averaging 33.9 ppt. Although this is a marine species in Florida, it can tolerate fresh water in aquaria, and it is an occasional invader of fresh waters in Cuba (Getter, 1976). In laboratory situations, mangrove mosquitofish were transferred to fresh water without dying. In one case where an adult male and female were transferred to fresh water, the female survived for over a year and the male survived for over 2 yr. However, it does not appear to be a facultative invader of fresh water in Florida.

Getter (1976) determined an exponential increase in brood size (Y) which follows the size of the gravid female (X) with the relationship, $Y = 3.67\ e^{00.9X}$, significant at $P = 0.001$, and that the fertility of *G. rhizophorae* is related to temperature.

Discussion—At the outset of this survey, it seemed that the distribution of the mangrove mosquitofish was related to that of the red mangrove. One of the initial purposes of this study was to examine the nature of what appeared to be a rare obligatory relationship. This was a result of numerous observations in sheltered-water habitats of the Florida Keys which are dominated by managroves. These observations now seem to be a simple autocorrelation. This became apparent when trying to explain the absence of the species in the expansive sheltered mangroves of Florida Bay. Failure by the species to invade the Everglades had been attributed to dependence upon red mangroves. This explanation became untenable when gravid females were found in collections from Cuban fresh waters; another explanation was necessary.

Baumgarten (1949) determined acute temperature tolerance in the

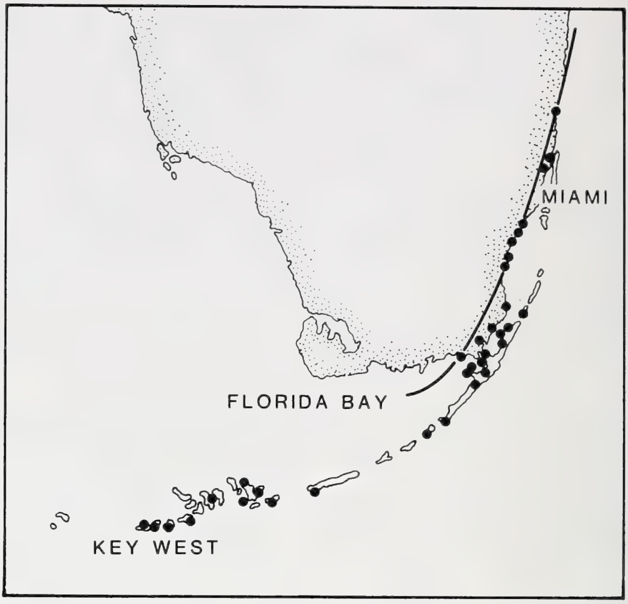

FIG. 1. Distribution of *Gambusia rhizophorae* in Florida in relation to mean low temperature for the January (17.0°C) isotherm. Temperature data from Bradley (1972).

mangrove mosquitofish to be 17°C. A 16.7°C (62°F) isotherm for southern Florida is in Fig. 1 along with the known Florida distribution of the mangrove mosquitofish. This isotherm, which corresponds to the minimum optimal temperature determined by Baumgarten (1949), intersects the shoreline at Fort Lauderdale and Shell Creek. These are the northern and western distribution limits for the species on the Florida mainland.

Failure of the mangrove mosquitofish to be found in fresh waters of southern Florida or in Florida Bay, therefore, may be due to the inability of the species to move across this isotherm which would require the species to tolerate lower temperature. A possible mechanism accounting for this failure to invade colder parts of Florida may be reproductive. Supporting this idea is Fig. 2, which plots the fertility index for females against monthly temperature changes. That mangrove mosquitofish are reproductively active in Cuban fresh water is consistent with a temperature-limitation explanation because winters are warmer there. Also supporting temperature limitation is the observation that the northernmost population of the mangrove mosquitofish is dwelling in a canal receiving heated effluent. These observations support the conclusion that the most limiting factor affecting the distribution of the mangrove mosquitofish appears to be its inability to tolerate the cooler winter temperatures in areas north and west of its range in southeastern Florida.

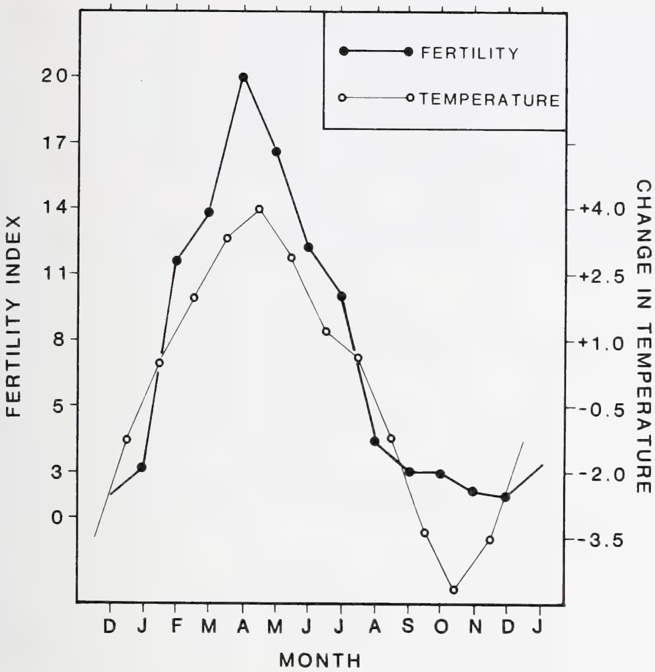

FIG. 2. Fertility index ratings of female mangrove mosquitofish by month, plotted with monthly changes in temperature. Temperature data from Bradley (1972).

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Florida Sci. 45(3): 196-200. 1982.

NOTES ON THE EGGS AND YOUNG OF *ANTILLOPHIS PARVIFRONS STYGIUS* (REPTILIA, SERPENTES, COLUBRIDAE)

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Abstract: Antillophis parvifrons stygius *was collected on Isla Saona, República Dominicana. A female that was gravid when collected laid 4 eggs on 22 July and 3 eggs on 4 September. The hatchlings differed in coloration and pattern from adults of* A. p. stygius *and were reminiscent of* A. p. paraniger. *Adult* A. p. stygius *exhibited dorsoventral neck flattening, but this behavior was not observed in the hatchlings.*

Little is known of the natural history of Hispaniolan colubrid snakes, including *Antillophis parvifrons.* Franz and Gicca's (in press) report on *A. p. alleni* from Ile de la Gonâve, Haiti, contains the only information on reproduction in the genus. *Antillophis p. stygius,* a medium-sized, unicolored black race, is endemic to Isla Saona off the southeastern coast of the República Dominicana. While conducting field work on Isla Saona in June-July 1980 and February-March 1981, a number of *Antillophis* was observed.

Two *A. parvifrons* were found within the village of Mano Juan, and several were also found in thorn scrub habitat. A portion of this habitat is figured in Henderson and Binder (1980: Fig. 10). They were especially common around shallow temporary pools of water within the thorn scrub habitat, taking cover within exposed root masses when disturbed. Body temperatures, taken on 2 snakes, were 29.9°C and 31.2°C; ground temperatures were 27.8°C and 30.2°C; air temperatures were 27.8°C and 31.2°C, respectively. The first temperature was taken at 1346 hr, the second at 1415 hr.

Three *Antillophis* (2 males and 1 female) were kept alive and maintained at the Milwaukee County Zoo. On 22 July 1980 the ♀ (SVL = 426mm; TL = 708 mm), which had appeared gravid when captured, laid 4 eggs, confirming oviparity in this species. Two of the eggs (numbers 3 and 4, Table 1) were yellow in color and soft to the touch. They showed white mold-like

TABLE 1. Egg Measurements of 2 clutches from *Antillophis p. stygius.*

	Length (mm)	Width (mm)	Weight (g)
CLUTCH #1			
Egg #1	34	11	2.68
Egg #2	32	11	2.55
Egg #3*	35	10	2.35
Egg #4*	33	11	2.45
$\bar{X}$ Clutch #1	33.5	10.75	2.51
CLUTCH #2			
Egg #1	32	—	—
Egg #2	32	—	—
Egg #3	30	—	—
$\bar{X}$ Clutch #2	31.3		

*Did not hatch.

growth within a week of laying and when opened showed no sign of embryonic development. The other 2 eggs were white in color with smooth, leathery, slightly adherent shells. On 28 and 29 September (67 and 68 da, incubation temperature 25-32°C, $\bar{X} = 29.4$°C) the 2 remaining eggs hatched.

On 4 September 1980 a second clutch of 3 eggs was found with the female. The eggs were adherent and somewhat desiccated, and only egg length was measured (Table 1). The female was housed with the 2 males between laying clutches, but neither courtship nor copulation were observed. This is the first indication of multiple clutches in *Antillophis.* Franz and Gicca (in press) reported 3-9 ($\bar{X} = 5.09$) maturing follicles or eggs in *A. p. alleni* but gave no indication of more than one clutch.

During incubation the eggs of the second clutch absorbed water and lost the desiccated appearance. All 3 eggs hatched in the early morning of 10 November 1980, after 67 da incubation. The hatchlings in the second clutch averaged 7.4% smaller in SVL and 6.4% smaller in TL than the first clutch, and egg lengths were 6.6% less in clutch number 2 (Tables 1 and 2).

The hatching date of 4 September for the first clutch corresponds well with peak monthly rainfall (18.5 cm) recorded for Santo Domingo (Ruffner,

TABLE 2. Hatchling sizes from 2 clutches of *Antillophis p. stygius.*

	Sex	SVL (mm)	TL (mm)
CLUTCH #1	F	156	253
	F	162	243
$\bar{X}$		159	248
CLUTCH #2	M	149	232
	M	141	231
	F	152	233
$\bar{X}$		147.3	232
$\bar{X}$ Both Clutches		152	238.4

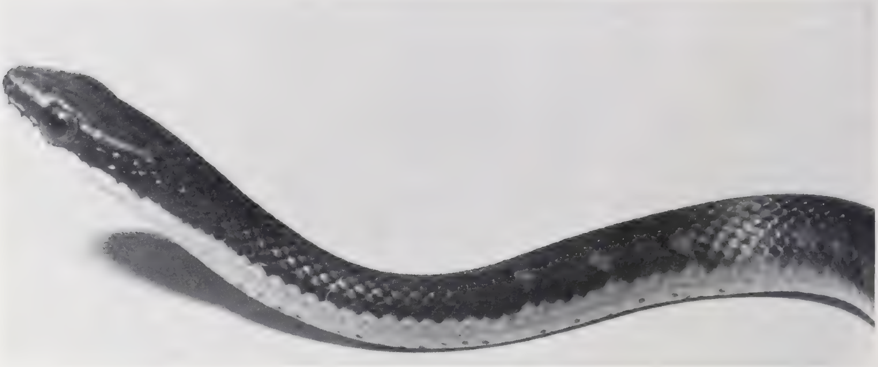

FIG. 1. Hatchling male *Antillophis p. stygius*, from second clutch, illustrating white lateral spots and light stripe on canthus rostralis and parietals.

1977) and it is likely that weather patterns on Isla Saona would be similar. The second clutch hatched on 10 November as both rainfall (12.2 cm in Nov) and temperature are declining (Ruffner, 1977). These hatching dates seem consistent with other reports from the western Caribbean: Fitch (1970) made reference to a *Tretanorhinus variabilis* from Cuba which laid 8 eggs on 1 August and which hatched on 4 September; an *Alsophis angulifer*, also from Cuba, which laid 9 eggs on 24 August and which hatched on 27 November; and a Bahamian *Epicrates striatus* which gave birth to 51 young on 19 September 1960.

The young snakes differed in coloration and pattern from the published description of adults of the subspecies (Thomas and Schwartz, 1965) and from adult specimens collected by us, although our adults agree well with their description.

The hatchlings, after the post-hatching skin shed (10-14 da post-hatching), differed from the adult description as follows: 1. Dorsal color slate grey. 2. Head and neck black with more or less distinct light stripe from the rostral scale along the canthus rostralis and continuing along the upper edge of the eye and outer edge of the parientals (Fig. 1). 3. Venter and tail grey, darkening posteriorly and washed with orange on rear half of body and tail. 4. Lowest 2 scale rows bluish-white, changing to grey posteriorly, but distinctly lighter then dorsal color. 5. All 3 second clutch hatchlings had a row of faint white spots on the neck and anterior of body (1-8 per side) on scales rows 5 and 6 (Fig. 1). 6. Both male hatchlings had a very faint suggestion of a mid-dorsal stripe on the neck, extending for about one head length. Many of these hatchling characteristics are reminiscent of Thomas and Schwartz's (1965) description of *A. p. paraniger*, a subspecies found on Hispaniola opposite Isla Saona.

During the first week of March 1981, 2 small *A. parvifrons* were collected at Mano Juan. Snout-vent lengths were 14.6 cm (MPM 19507) and 14.2 cm (MPM 19525) and both snakes had color and pattern similar to those hatched in captivity.

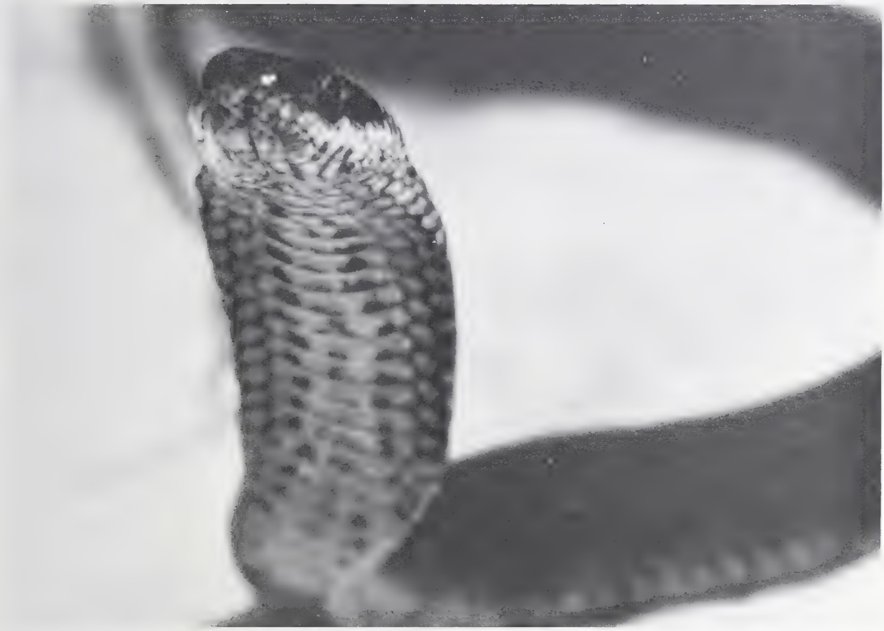

FIG. 2. Adult *Antillophis p. stygius*, illustrating dorsoventral flattening of the neck in a typical defensive posture.

Schwartz (1978) and Thomas and Schwartz (1965) describe dorsoventral neck flattening in *A. p. stygius*, and we also saw this behavior in adult specimens captured (Fig. 2), but none of the 5 hatchlings exhibited this behavior.

Specimens are, or will be, deposited in the herpetological collection of the Milwaukee Public Museum (MPM).

ACKNOWLEDGMENTS—Funding for field work by Henderson in the República Dominicana was provided by Friends of the Milwaukee Public Museum, the Fundación Gulf + Western Dominicana (Campos S. de Moya, Director) and the Museo Nacional de Historia Natural in Santo Domingo. In the República Dominicana, the kind hospitality of Sixto J. Incháustegui M. and José Alberto Ottenwalder of the Museo Nacional de Historia Natural made potentially time-consuming tasks relatively effortless. Mary H. Binder and Sandra A. Sajdak worked with us in the field. Clifford Van Beek assisted in maintaining the live snakes. Richard Franz and Diderot Gicca sent us a copy of their manuscript prior to publication. To all of these people we express sincere appreciation.

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HYPERTENSION IN A WEST INDIAN POPULATION

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Abstract: *We used survey methods to characterize hypertension in a relatively isolated West Indian population. Results indicated that excellent discrimination between hospitalized and nonhospitalized hypertensives and controls was available using the following variables: age, gender, weight, family history, herb usage, salt intake, smoke intake, anxiety, and personal problems. These findings support previous work on high blood pressure in populations from other Western nations.*

Cardiovascular diseases are a major cause of mortality in adult populations. Documentation of the diseases for many developed North and South American countries have been reported (Pan American Health Organization, 1977). However, in developing countries this information is often not available. We attempted to delineate those variables associated with hypertension in hospitalized and nonhospitalized samples of a relatively isolated West Indian population.

Phase 1—In October 1978, randomly-distributed questionnaires (with self-addressed, stamped envelopes) were forwarded to 250 individuals living in the southern half of Grenada, West Indies. Participants for the first of 2 studies included the 50 persons who returned a completed questionnaire. Of these 50, the 32 who reported having been diagnosed and treated by a physician for high blood pressure comprised the experimental group. The remaining 18 which had not been diagnosed or treated for hypertension formed the control group.

The following variables were included in the 46 item questionnaire: age, residence, gender, weight, race, religion, occupation, personal history of hypertension, length of illness, family history of hypertension, which family members, kidney problems, diabetes, 3 most preferred foods, appetite, salt use, alcohol intake, frequency of alcohol consumption, stomach aches, frequency of aches, quality of aches, vomiting, frequency of vomiting, smoking, frequency of smoking, breathing problems, personal problems (i.e., psychological problems which impaired social, occupational, and self care functioning), sleep characteristics, sight, headaches, weakness, perception of weakness, nervousness, frequency of nervousness, dizziness, frequency of dizziness, faintness, frequency of faintness, forgetfulness, frequency of forgetfulness, use of herbs for hypertension, type of herbs, and response to herb use. Questionnaire wording and response scales were validated with a pilot project using Grenadian natives (validation data and sample questionnaires available upon request).

Of the 46 variables measured, 9 were identified using measures of central tendency as having more than negligible ability to separate responders reporting hypertension from those who did not. These were: age, gender, weight, family history, herb usage, salt intake, smoke intake, nervousness, and personal problems. The results indicate that an individual would report being hypertensive if they were older than 50 and had a family history of hypertension, typically parents. They used herbs including "dragon blood", "collie paw paw", "corilley", "love leaf", "paupa leaf", and yellow breadfruit leaf to reduce symptions of hypertension and to elicit a state of well-being. Additionally, those reporting hypertension tended to feel chronic diffuse anxiety. These anxieties presumably could have been related to the numerous personal problems listed. These problems usually involved financial and family matters. Furthermore, the experimental group reported frequent use of salt and smoking tobacco. Finally, this group tended to be female and overweight.

When these 9 variables were used in a multivariate discriminate analysis (Morrison, 1976) using SAS 1976 (Barr, Goodnight, Sall et al., 1976), the resulting discriminate function correctly classified all individuals of the control group and 95% of the hypertensive group. The coefficients for the linear discriminate function are in Table 1.

Phase 2—In the second survey, 136 patients from St. George's General Hospital (St. George's, Grenada) hospitalized between August and December 1978 volunteered. The 78 experimental subjects had been diagnosed by the attending physician as hypertensive and blood pressure reading matched or exceeded the Pan American Health Organization's criteria (age 20-29—150 and/or 90, age 30-64—160 and/or 95, and age 65 or older—170 and/or 95). The mean blood pressure for this group was 187/113. Blood pressure readings were ascertained using standard sphygmomanometer while patients were in a supine position. For this study, one complete week of blood pressure readings were used to determine average admitting pressure. The control group was comprised of 58 hospitalized patients not meeting the Pan American Health Organization (PAHO) criteria (mean = 130/84).

Variables included in this phase are in Table 2. Patients were interviewed at bedside on weekday afternoons by the senior author.

It was predicted that the 9 variables used in Phase I would be useful in discriminating hospitalized groups. Although nervousness was not measured in this Phase, the discriminate analysis using the remaining 8 variables correctly classified 77% of the control and 83% of the hypertensive group. Thus, it appears that similar variables differentiated hypertensives from controls both in and out of the hospital.

Approximately 35% of all female and 25% of all male patients at St.

TABLE 1. Coefficients of the discriminative function used in Phase I.

Variable	Value of Coefficient
Smoking	11.861
Family History	8.815
Personal Problems	8.317
Nervousness	5.672
Gender	2.901
Herb Use	1.905
Salt Intake	1.721
Weight	.911
Age	.274

TABLE 2. Variables measured in Phase II.

Category	Variables
Demographic	age, gender, weight, race, occupation, religion
Medical	admitting blood pressure, family history of hypertension, number and relation of family members with hypertension, personal history of hypertension, stomach pains, nausea, visual impairment, headache frequency and intensity, convulsions, loss of consciousness
Food and Substance	3 most preferred foods, appetite, salt intake, alcohol consumption, smoking, use of herbs for hypertension
Behavioral	type of personal psychological problem, sleep habits, weakness

George's medical-surgical wards were diagnosed as and met the PAHO criteria for hypertension. The mean blood pressure at discharge for hypertensives was 130/84.

DISCUSSION—The following variables best discriminated between hypertensives and controls in the populations studied: age, gender, weight, family history, herb usage, salt intake, smoke intake, anxiety, and personal problems. It appears that even with the restricted samples these variables could discriminate hypertensives with accuracy ranging from 77-100%.

These findings provide a preliminary view of variables associated with hypertension in a relatively isolated population of an undeveloped Western nation and extend the results of investigations performed in developed American countries. Ashcroft and Desai (1978) found that in a rural Jamaican population an increase in mortality may have been related to the significantly elevated blood pressures observed. Cruickshank, Beever, Verdelle, Osbourne, Haynes, Corlett, and Selby (1980) reported that while West Indians living in England had fewer heart attacks than either natives or Asians, they also had proportionally more strokes which presumably were related to the increased incidence of high blood pressure in West Indians. In developed Western nations, smoking (Public Health Service, 1979), genetic predisposition (Friedman and Iwai, 1976), coronary-prone behavior patterns (Friedman and Rosenman, 1972; Kenigsberg, Zyzanski, Jenkins et al., 1974), salt intake (Dahl and Love, 1961), and obesity (Kannel, Brand, Skinner et al., 1967) appear to be related to hypertension. While many variables appear to be common to different areas, there is an indication that their relative contribution in discriminating hypertensives may vary according to locality and population.

Acknowledgments—Data were gathered during the senior author's tenure at St. George's University, Grenada, West Indies. We thank Dr. Budhlall from St. George's General Hospital for his assistance.

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Florida Sci. 45(3): 203-207. 1982.

REVIEW

Robert K. Godfrey and Jean W. Wooten. *Aquatic and Wetland Plants of Southeastern United States: Dicotyledons.* Pp. i-x; 1-933. 399 figs (September 8, 1981), University of Georgia Press, Athens. Price: $40.00.

Just two years, two months and 21 da passed before appearance of the second and concluding volume of this long anticipated *magnum opus.* Florida botanists, ecologists and others concerned with plant identification cannot afford to be without both volumes of *Aquatic and Wetland Plants of Southeastern United States.* Not that the whole flora of Florida is included because it is not, but the interpretation of wetlands is very broad as the authors have "indulged personal biases" which seem to this reviewer to come down mostly on the side of inclusion of all but very rare and local wetland species. A rough count of taxa covered includes 106 families, 369 genera, 1147 species and numerous subspecific entities. As in the previous volume, illustrations were derived from a variety of sources, including some original figures, but there is a remarkable uniformity among all 399 in presentation and in consistently high quality. I would have liked to see at least one illustration for each genus, but that would have added 169 more figures. Perhaps we will not suffer unduly for the lack of a drawing for *Salix*, *Celtis*, *Rubus*, *Catalpa* or *Xanthium* but less sophisticated users will face some frustrations while giving thanks for the excellent likenesses that are present.

The keys to families seem eminently workable. Because of variability within some families, several may be keyed out in more than one place—a system far superior to that of "purists" who insist that any element should appear but once. Keys to genera within a family appear in the text immediately following a brief family diagnosis. Species are keyed following the generic diagnosis and comments. Occasional personal comments are both relevant and very practical. The authors note on oaks (*Quercus*), for instance, ". . . given species exhibit a considerable degree of variability of leaves, those of sprouts and sucker shoots often differing considerably . . ." They go on to say "In some cases, . . . it is essential to know the distinctive features of involucral cups and acorns." Thus, the inexperienced user is directed to features of greatest value for resolving difficult determinations.

A high degree of scholarship and first hand knowledge of the plants is evidenced throughout the work. Descriptions are crisp and diagnostic without being tiredly uniform and somewhat mechanical in presentation, but still sufficient to inspire confidence in the user's identification. Both volumes are well bound in dark green cloth and the fascicles are sturdily sewn in such a manner that the book will remain open while in use. The University of Georgia Press has given us a new standard reference work which merits strong praise for both the authors and publishers. At $40.00 for the very large second volume and $70.00 for the set, the cost is reasonable in today's technical book market. Every aquatic biologist and systematic botanist ought to have a copy on the shelf.—*H. A. Miller*, University of Central Florida, Orlando 32816.

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FLORIDA SCIENTIST

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Engineering Sciences

ENERGY MODELS FOR VOLUSIA COUNTY, FLORIDA

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ABSTRACT: *An overview energy analysis model was developed for Volusia County, Florida. It was aggregated to include driving functions causing change from outside the county, and the main categories of land use in the county, including natural, agricultural, and urban assets. Computer simulation of a simplified model suggests trends to be expected in growth and land use for various alternative energy conditions. The increasing ratio of outside purchased resources to local environmental resources is used to estimate the population and development to be expected assuming continued rises in price of fuels and fuel-based goods and services.*

WE discuss 3 critical problems that Volusia County faces now and in the near future:

1. How many people can Volusia County optimally accommodate and is there a necessity to limit the population growth?
2. What is the relationship of energy and the ecology of Volusia County, and what effects will future energy shortages have on quality of life?
3. What is the relationship of density of development with the necessity to import and export, and what might be the long term vulnerability of a county that relies extensively on outside areas for supply and markets of goods and services?

The State of Florida is one of the fastest-growing states in the United States with the distinction of having the largest numerical increase of any state in the nation. Central Florida's population increased by 44% in the 1960-70 decade. Volusia County (Fig. 1), a county on the east coast of Central Florida, had a population increase of 35% in the same time period and a 43% increase in the 1970-80 decade. Volusia County has long been one of the favorite tourist centers on the upper east coast of Florida. Today, Daytona Beach and most of the cities within the county host some 5.5 million tourists annually who enjoy both the man-made and natural areas,

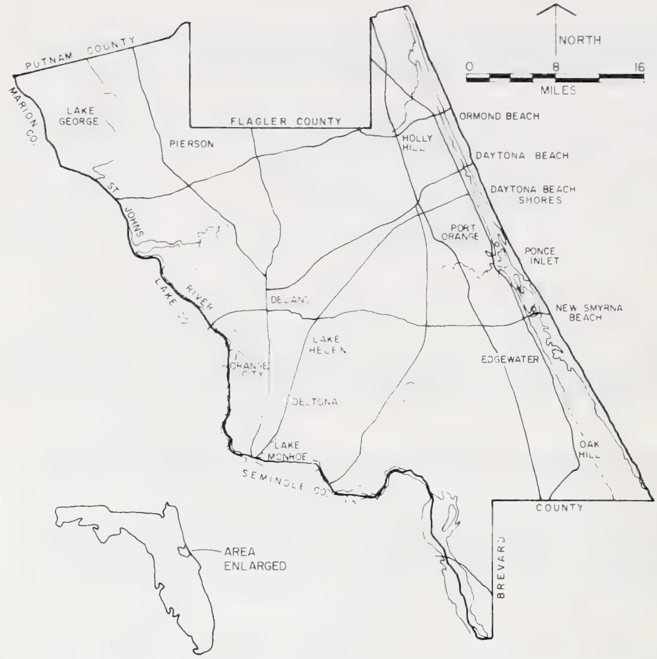


Fig. 1. Volusia County and surrounding central Florida counties.

including the ocean, beaches, lagoons, rivers, lakes, springs, woodlands, and other amenities. Volusia County is comprised of over 315,333 ha of well-drained uplands, flatwoods, swamps, marshes, agricultural and urban land; 18 municipalities; and a population of over 242,000 (1980). The County population is currently increasing at a rate of about 4% per year.

New methods of examining regional growth have been proposed combining energy concepts and systems analysis (Odum and Brown, 1975; Brown, 1980; and Odum and Odum, 1981). These authors suggest ways to estimate future trends and the carrying capacity that an area has for prosperous population and economic development. In this paper these methods are tested in Volusia County, Florida. Other efforts to develop energy analysis and models in Florida include those by Boynton (1975) for Franklin County; Zucchetto (1975) for Dade County; Brown (1976) for Lee County; DeBellevue (1976) for Hendry County; Lehman (1976) for Collier County; and Sipe, Swaney, and McGinty (1979) for Hillsborough County.

Methods and Materials—A detailed energy flow diagram was prepared of the main components and outside influences on the county, using energy systems symbols following Odum (1971, 1981). To evaluate the storages (state variables) and flows of the model, statistics were used from county and state sources for assets and economic flows. The categories of land use were delineators from a map of the subsystems of Volusia County prepared by the Center for Wetlands at the University of Florida under contract to the St. Johns River Management District. Imports and exports were estimated from a general nomograph which was made by analyzing, from other counties, the proportion of occupations which were more frequent than U.S. averages and thus involved export activity.

From the evaluated diagram, perspectives on the future were obtained by comparing the coal equivalent investment ratio with those of other areas. The investment ratio is defined as the input of purchased fuel, goods, and services divided by the environmentally based flow of renewable energies, both expressed in Calories of embodied energy of the same type. Coal Equivalent Calories (C.E. Cal) are used in this paper. (For a detailed explanation of C.E. Calorie and methods of calculation, see Odum, 1981). The ratio for the United States for 1980 is:

$$\frac{\text{Invested Energy}}{\text{Free Energy}} = \frac{\text{Fossil Fuel Energy}}{\text{Solar Energy}} = \frac{20.99 \text{ x } 10^{15} \text{ CE Cal}}{6.74 \text{ x } 10^{15} \text{ CE Cal}} = 3.1/1$$

This ratio provides a useful index of the competitive balance of natural and purchased energies and can be used to compare with areas that are proposing further growth and economic development.

Economic development is postulated to occur when the investment ratio is low, because this means that relatively more local resources exist to attract investments and immigration. Embodied energies are the Calories of one type of energy, such as coal equivalents, required to generate some other type product. Expressing all energies in equivalent Calories of one type is a simple way to relate relative energies required to develop and maintain aspects of humanity and nature. The ratio of Calories of one type of energy required to develop calories of another is the energy transformation ratio (ETR). For example 4 coal calories are required to develop 1 Calorie of electricity.

To develop an evaluation of the flows and storages of Volusia County in units of the same type of energy, each storage and flow was first assessed for its actual energy and for its dollar flow where appropriate. The energy transformation ratio for that type of flow was then multiplied to obtain an estimate of Calories of coal equivalent energy. The flow of dollars represents payments for goods and services which have converged from environmental energies, fuels, and goods and services that flow in from the outside. These represent the embodied energies of production processes elsewhere. An average ratio of dollar circulation to total embodied energy used is the general dollar-energy ratio. This ratio decreases each successive year due to inflation. The dollar-energy ratio for the year in which a statistic was obtained is multiplied by the dollar flow to obtain embodied energy in the goods and services of that flow.

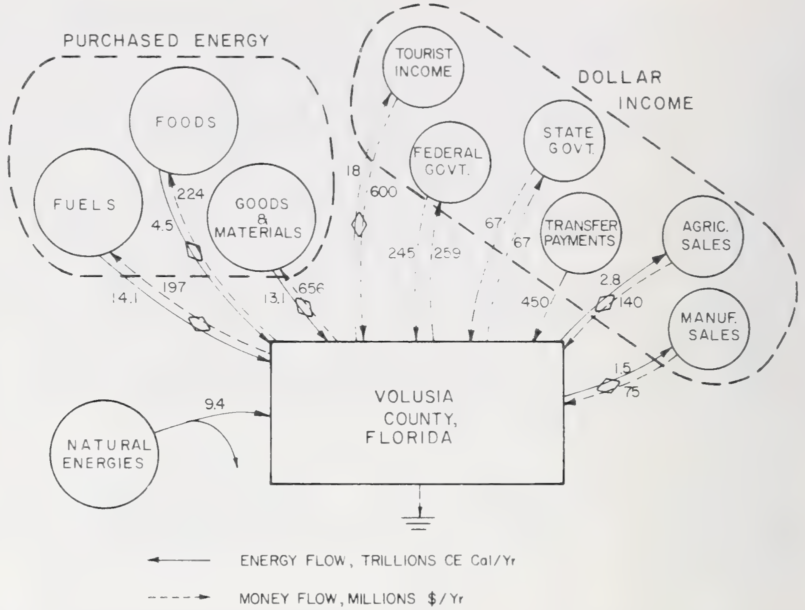


FIG. 2. Simplified diagram of Volusia County's balance of payments: inputs and outputs of energy and money.

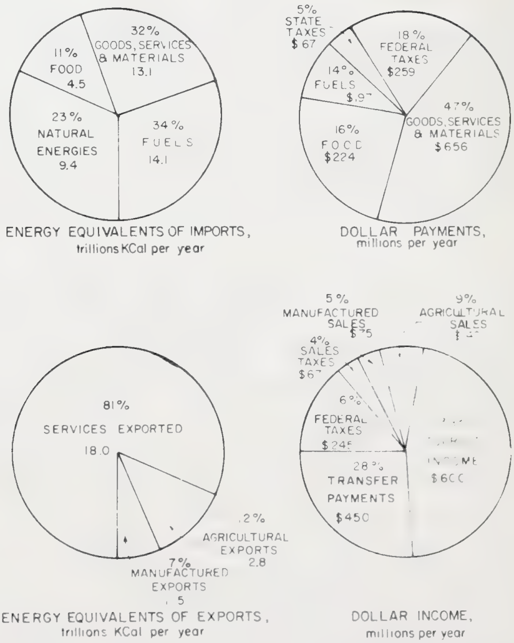


FIG. 3. Distribution of money and energy in Volusia County, Florida.

Because the energy diagramming allows easy development of kinetic as well as energetic relationships, differential equations can be written as a translation of the energy diagram. These equations are a systems description of the system as it is perceived. Computer simulation models were developed and run on analogue and digital computers to extrapolate past and future trends based on alternatives considered for external factors.

RESULTS — The results of energy evaluations for Volusia County are in Figs. 2 and 3. Table 1 gives the subsystem classification of Volusia County land use with structure and metabolism values. The nomograph in Fig. 4 shows the interrelationship between density of development and total exports of selected Florida counties. The detailed systems model and simplified simulation model of Volusia County are in Figs. 5 and 6, respectively. Simulation graphs of past and future trends are in Fig. 7. Notes and calculations explaining the basis for various data and coefficients used are in Table 2 and the Appendix.

Figure 2 is a simplified diagram showing the county's inflows and outflows. This figure shows the major flows of energies and materials and their accompanying money flows that cross county boundaries. Goods sold and money received are shown to the right, and imports along with expenditures are shown to the left. Energy flows are expressed in kilocalories and the diamond symbol represents the exchange, or price of energy flow, with money flowing in the opposite direction to the flow of energy.

Note that 38% of the county's income is from tourism. Transfer payments represent 28% of total income and 14% is derived from the sale of agricultural products and manufactured goods. By examining the balance of payments diagram (Fig. 2) and the pie diagram (Fig. 3), it becomes clear where real energy consumption lies. When the 14.1 trillion Cal used as gasoline, diesel fuel, natural gas, and the bunker "C" oil used for the generation of electricity is compared to the flow of goods, services, and materials (13.1 trillion Cal) it is seen that the energy embodied in goods and services purchased is almost equal to the fossil fuel consumed for transportation, home water heating, and electrical generation. To conserve energy, it may be necessary to reduce consumption of goods and services that have high embodied energies as well as direct attempts to cut down on fossil fuel consumption.

In Fig. 3 it should be noted that 66% of Volusia County's income is derived from tourist spending and transfer payments. Because both of these income sources are strongly subject to fossil fuel availability, inflation, and the national economy, extreme fluctuations in the local economy are possible which could seriously decrease the standard of living in Volusia County.

Because Volusia County's major income is from tourism (38%), the effect of the "Regional Image" in attracting tourists is vital. The county's image is dependent upon both its natural and urban assets. If the image of the county remains greater than that of other popular tourist-attracting counties, additional tourists will be attracted to Volusia County.

Table 1. Subsystem classification, acreage, structure, and metabolism for Volusia County, Florida.

Subsystem Classification	Subsystem Acreage (a)	Subsystem Structure* CE Cal/ac x 10^5 (b)	Total Subsystem Structure CE Cal x 10^{12}	Metabolism Density of Subsystems** CE Cal/ac/yr x 10^6 (c)	Total Subsystem Metabolism CE Cal/yr x 10^{12}
I. URBAN					
Open Land	24,819	24.7	0.613	7.7	0.191
Recreation	960	24.7	0.024	7.7	0.0074
Residential— Low Density	1,558	750.0	1.158	250.0	0.390
Residential— Med. Density	32,895	2,250.0	74.014	520.0	17.105
Residential— High Density	709	2,250.0	1.595	1,600.0	1.134
Industrial	70	11,125.0	0.779	1,600.0	0.112
Mining	240	100.0	0.024	50.0	0.012
Commercial and Services	2,002	11,125.0	22.272	1,600.0	3.203
Institutions	528	10,000.0	5.280	1,500.0	0.792
Transportation	2,642	2,000.0	5.284	500.0	1.321
Utilities and Communication	160	126,000.0	20.160	4,000.0	0.640
Total	66,583	165,649.4	131.203	11,635.4	24.9074
II. AGRICULTURE					
Improved Pasture	32,527	24.7	0.803	5.1	0.0068
Cropland	4,056	294.8	1.196	21.3	0.086
Citrus Groves	15,395	74.9	1.153	5.7	0.088
Nursery and Special Crops	464	294.8	0.137	21.3	0.0099
Confined Feeding	65	294.8	0.019	21.3	0.0014
Planted Pine	60,713	80.1	4.863	6.4	0.389
Clear Cut Areas	3,725	24.7	0.092	0.5	0.0019
Other	13,512	24.7	0.334	0.5	0.0068
Total	130,457	1,113.5	8.597	82.1	0.5898

		III. NATURAL			
Grassy Scrub	31,153	16.5	0.514	4.0	0.125
Sand Pine Scrub	16,929	90.0	1.524	6.4	0.108
Sandhill Comm.	2,787	80.1	0.223	6.4	0.018
Pine Flatwoods	174,983	80.1	14.016	6.4	1.120
Xeric Hammock	281	200.0	0.056	7.0	0.002
Mesic Hammock	16,247	235.9	3.833	7.7	0.125
Hydric Hammock	5,318	235.9	1.255	7.7	0.041
Hardwood Swamp	116,788	231.0	26.978	7.7	0.0061
Riverine Cypress	53,950	229.2	12.365	7.3	0.394
Cypress Domes	5,292	214.5	1.135	7.3	0.039
Bayheads & Bogs	617	175.0	0.108	5.0	0.0031
Wet Prairies	2,595	51.6	0.134	5.4	0.014
Fresh Water Marsh	39,509	228.7	9.036	7.4	0.292
Total	466,449	1,839.8	71.1717	85.7	2.2872
		IV. OPEN WATERS			
Rivers and Streams	31,899	77.4	0.024	1.4	0.045
Lakes and Ponds	61,387	7.4	0.045	1.4	0.086
Reservoirs	1,078	228.7	0.025	7.4	0.008
Borrow Pit	62	3.5	0.0002	0.7	0.00004
Total	94,426	317.0	0.0942	10.9	0.13904
		V. COASTAL WATERS			
Tidal Flat	0	4.0	0.0	0.3	0.0
Beach and Dune	886	4.0	0.0035	0.3	0.0002
Coastal Hammock	3,428	235.9	0.809	7.7	0.026
Salt Marsh	15,525	29.5	0.458	5.0	0.078
Mangroves	750	218.4	0.164	7.3	0.0055
Spoil Bank	80	5.0	0.0004	0.3	0.00002
Total	20,669	496.8	1.4349	20.9	0.10972

a—area measurements derived from land use maps of Volusia County, prepared by the Center for Wetlands, University of Florida.

b—estimates of structure from Odum and Brown, editors (1975).

c—estimates of gross primary productivity from Odum and Brown, editors (1975).

*—structure is total biomass converted to Cal of coal equivalents using a conversion factor of Cal/kg dry weight.

**—metabolism is gross primary production estimated as Cal/m²/day from literature.

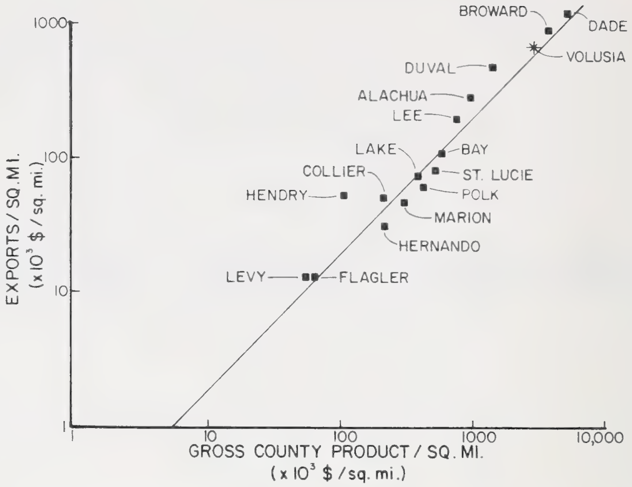


FIG. 4. Development density vs. exports showing the increasing reliance on an export based economy with incoming development of counties in Florida (Brown, 1980).

The "Free Natural Energies" flowing into Volusia County (in coal equivalent Cal/yr x 10^{12}) total some 9.4 and divide themselves as follows (Appendix): sunlight—4.31; chemical potential of rain—2.76; tides—1.04; wind—1.0; waves—0.16; kinetic energy of rain—0.12; kinetic energy of river flow—0.02. The inflow labelled "Fuels" includes all fuel (CE Cal/yr) such as gasoline and diesel fuel—(4.01 x 10^{12}); heating oil (2.98 x 10^{11}); natural and liquid gas (3.80 x 10^{12}); and the fuel used to generate electricity (5.98 x 10^{12}). The inflow labelled "Food" is the embodied energy value (4.5 x 10^{12} CE Cal/yr) of the food consumed annually. The energy value of the "Goods and Materials" (13.1 x 10^{12} CE Cal/yr) imported is the fossil fuel embodied value of the goods to Volusia County.

Energy Investment Ratio: Figure 2 shows the purchased energies or external energy sources utilized by Volusia County and the accompanying money exchanges. The solid lines represent the flow of goods and energies that cross the boundaries of Volusia County, expressed in coal equivalent kilocalories per year. The various natural energies are also accounted for and represent the free work that nature performs. Typically, the free work of nature goes unnoticed by man, but even though these solar based energies are of a lower quality than fossil fuels, their abundance makes their overall work contribution large. A region like Volusia County with abundant free energies attracts outside investment and is more competitive than an area without natural subsidies. The calculations in this study show the following investment ratio for Volusia County (1980):

$$\frac{\text{Fossil Fuel Energy}}{\text{Natural Residential Energy}} = \frac{42.2 \text{ x } 10^{12} \text{ CE Cal}}{9.4 \text{ x } 10^{12} \text{ CE Cal}} = 4.5/1$$

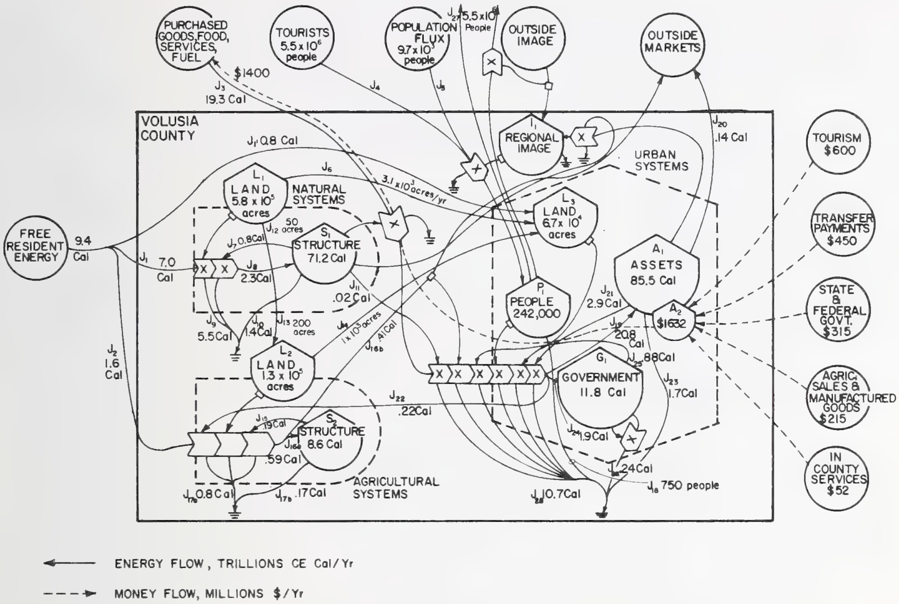
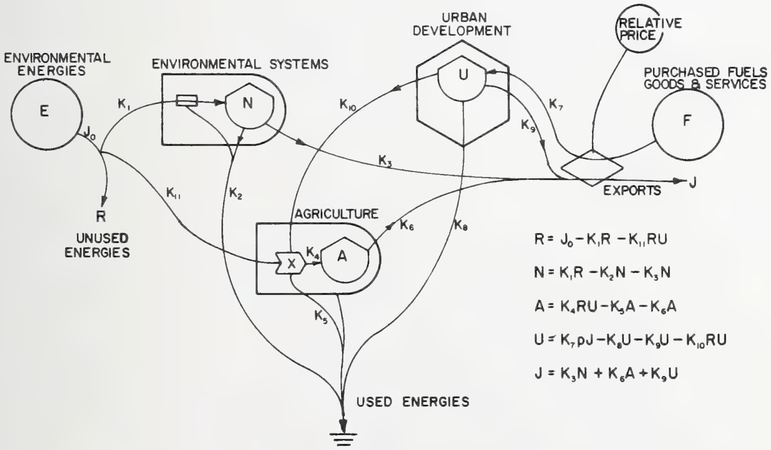


FIG. 5. Detailed systems model of Volusia County, Florida.



$$R = J_0 - K_1R - K_{11}RU$$

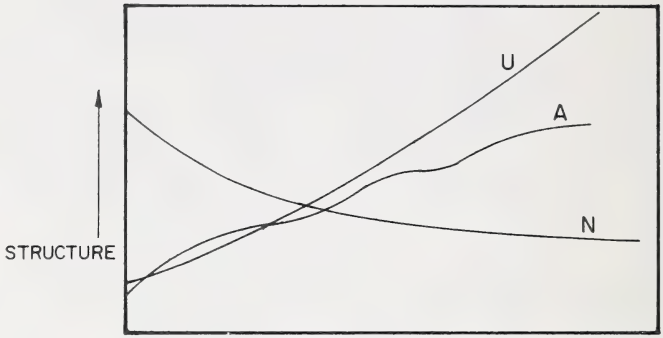
$$N = K_1R - K_2N - K_3N$$

$$A = K_4RU - K_5A - K_6A$$

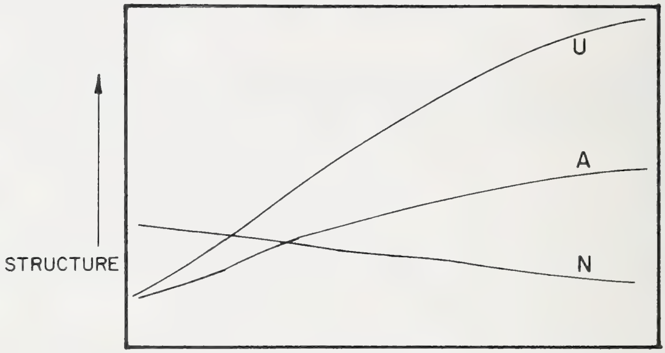
$$U = K_7pJ - K_8U - K_9U - K_{10}RU$$

$$J = K_3N + K_6A + K_9U$$

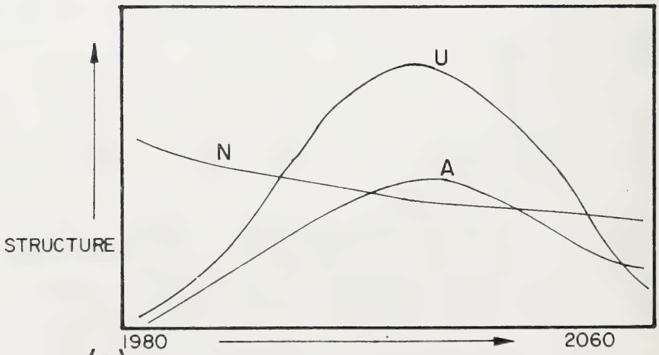
FIG. 6. Simplified simulation model and equations for Volusia County, Florida. Symbols of energy circuit language: circle = energy source; tank = energy storage; bullet = producer unit; hexagon = consumer unit; diamond = economic exchange; pointed blade with x = multiplicative interaction.



(a) PRESENT RATE OF CONSUMPTION



(b) SIMULATION FOR FUTURE WITH UNLIMITED FOSSIL ENERGY



(c) SIMULATION FOR FUTURE WITH DECREASING FOSSIL ENERGY

FIG. 7. Graphic simulation results from simplified model in Fig. 6: U = Urban Systems; A = Agricultural Systems; N = Natural Systems.

TABLE 2. Summary of data for the simulation model in Fig. 6.

Sources of Compartments	Amount	Notes
E	9.4 x 10^{12} CE Cal/yr	Summarized from total natural energies (Appendix)
N	71.2 x 10^{12} CE Cal/yr	Total of Natural Subsystem Structure (Appendix)
A	8.6 x 10^{12} CE Cal/yr	Total of Agriculture Subsystem Structure (Appendix)
U	105.8 x 10^{12} CE Cal/yr	Total of Urban Assets, Govt., Agric. Yield, Urban Energies, Agric. Energies (Appendix)
F	Fluctuating	Fuel prices subject to world market

Flow	Amount	Notes
K_1	7.0 x 10^{12} CE Cal/yr	J_1 (See Appendix)
K_2	1.4 x 10^{12} CE Cal/yr	J_{10} (See Appendix)
K_3	0.02 x 10^{12} CE Cal/yr	J_{11} (See Appendix)
K_4	0.59 x 10^{12} CE Cal/yr	J_{16_a} (See Appendix)
K_5	0.17 x 10^{12} CE Cal/yr	J_{17_b} (See Appendix)
K_6	0.41 x 10^{12} CE Cal/yr	J_{16_b} (See Appendix)
K_7	19.3 x 10^{12} CE Cal/yr	J_3 (See Appendix)
K_8	1.71 x 10^{12} CE Cal/yr	J_{23} (See Appendix)
K_9	0.14 x 10^{12} CE Cal/yr	J_{20} (See Appendix)
K_{10}	0.22 x 10^{12} CE Cal/yr	J_{22} (See Appendix)
K_{11}	1.6 x 10^{12} CE Cal/yr	J_2 (See Appendix)

Investment ratios for different regions of Florida have been calculated as follows: rural north central Florida—1.7/1 (Kemp et al., 1976); Brevard County in 1970—2.33/1 (Bayley et al., 1976); South Florida as a whole—2.9/1 (Brown, 1976), and Dade County—4.0/1 (Zucchetto, 1975). Brown (1976), using Zucchetto's (1975) data, calculated an investment ratio for Miami of 11/1. However, these South Florida ratios may be somewhat exaggerated because areas in South America conveying economic support to South Florida were not appraised. With the extraordinary rate of development over the county, extrapolations for conceivable future populations of 350,000 or 500,000 yield high investment ratios of 6.5/1 and 9.3/1, respectively. These ratios start to approach those of Miami which is regarded by most planners as far above an optimum population density. Volusia County, with higher investment ratios, reflecting a higher fuel subsidy, may suffer a more acute reduction in "standard of living" should fossil fuel energies continue to be limited. Volusia County may need to seek methods for lowering the fossil fuel usage by making more efficient use of natural energies. Without this, economic hardships and a reduction of the standard of living may result.

Development Density: Recent studies of the relationship of the density of development (as measured by Gross Domestic Product (GDP) per square mile) to the total exports per square mile of a region are plotted in Fig. 4. The graph shows the relationship between the density of development of a region and its requirements for exporting and importing needed materials, energies, and services. Theory suggests that the more developed a region, the more are its requirements to import and export; thus the more is its dependence on outside regions (Brown, 1980).

Shown in Fig. 4 is a graph of GDP per square mile versus exports per square mile for selected Florida counties. When data for Volusia County are extrapolated from the graph, indications are that Volusia County is more developed on the average than other Florida counties and relies more heavily on outside sources of energy and materials.

Should instabilities and recessionary trends in the national economy continue, Volusia County may feel these effects more than other counties in Florida, because of its greater than average dependence on outside areas. Continued growth and development of the county increases the development density which results in increasing vulnerability to fluctuations in national economic outlook.

Aggregated Model — Because the detailed model (Fig. 5) is highly complex, an aggregated version was drawn which is a synthesis of the most important details of the more complex model and is in Fig. 6, with differential equations. The model was simulated on an EAI Miniac Analog Computer and a digital computer for trends of land use as a result of an increasing outside energy source.

Simulation Results — The graph of the computer simulation in Fig. 7a gives a historical perspective on land use trends from 1900 to the present. As a result of increased energy availability, there was growth of the urban and agricultural systems. The simulation shows the decline of lands that were in natural productivity as they are converted to urban and agricultural uses, and agricultural uses in turn show a decline in the later years of the simulation as more and more land was converted to urban uses.

The graph in Fig. 7b results from simulations of the model when coefficients are adjusted to suggest continuous availability of cheap fossil fuel energies in the future. Growth of both urban and agricultural assets continues and the decline of natural production as a result, is evident. Toward the end of the simulation, however, a decline in the growth rate is observed. Because attraction of outside energies is in part dependent upon natural lands, as the area of these lands diminish, the attractiveness of Volusia County for investment declines, dampening further growth of urban and agricultural assets.

The graph in Fig. 7c shows future trends as a result of model simulation when coefficients are adjusted so that prices of outside purchased fuels, goods, and services increase relative to the price of exports from Volusia County. In essence, the buying power of income generated from exports shrinks. Availability of fuels, goods, and services will thus decrease. With declining availability of these energies, growth of the urban and agricultural assets is arrested and decline to levels that are near those prior to the 1970s, because urban and agricultural structure cannot be maintained without those very necessary inputs of high quality bought energy.

Because of the constant change in external factors and regional information, the evaluation and simulation of Volusia County must be considered as simplified overviews and quantitative hypothesis to be improved. Nonetheless, like a controlled experiment, holistic models are useful to determine relative magnitudes and the consequences of variation in factors.

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Appendix

Notes and Calculations to Figure 5.

Stocks	Value	Source
L_1 Natural Land	5.8 x 10^5 acres	St. Johns River Water Management District land-use map (Table 1.)
S_1 Natural Structure	71.2 x 10^{12} Cal/yr	Table 1.
L_2 Agricultural Structure	1.3 x 10^5 acres	Table 1.
S_2 Agricultural Structure	8.6 x 10^{12} Cal/yr	Table 1.
I_1 Regional Image		Assumed
P_1 Population	242,000 people	1980 Census data
L_3 Urban Land	6.7 x 10^4 acres	Table 1.
A_1 Urban Structure	85.5 x 10^{12} Cal/yr	Real and personal property for Volusia Co. (1977) – \$ 2.8 x 10^9; Non-exempt property – \$ 3.3 x 10^8; Estimated value for autos, clothing, and furniture – \$ 7.2 x 10^8; Bank savings – \$ 4.9 x 10^8; Savings and loan assets – \$ 4.3 x 10^8; totaling – \$ 4.77 x 10^9 x 13,800 CE Cal/yr = 6.58 x 10^{13} + 10% annual increase (3 yrs) = 8.55 x 10^{13} CE Cal/yr
A_2 Urban Monetary Assets	\$ 1632 x 10^6	Sum of monetary inflows from Figure 2.
G_1 Government Assets	11.84 x 10^{12} CE Cal/yr	1977 Vol. Co. Tax Assessor's values from 14 municipalities – \$5.5 x 10^6; Vol. Co. Govt. properties – \$3.47 x 10^8; State Govt. properties – \$ 1.8 x 10^8; Federal Govt. properties – \$ 6.8 x 10^7; totaling – \$ 6.6 x 10^8 x 13,800 CE Cal/yr = \$ 9.11 x 10^{12} + 10% annual increase (3 yrs) = 11.84 x 10^{12} CE Cal/yr

Flow	Description	Value	Sources
J_1	Natural energies on natural lands	7.0 x 10^{12} CE Cal/yr	74% of total natural energies on land areas
J_1'	Natural resident energies on urban lands	0.8 x 10^{12} CE Cal/yr	9% of total natural energies based on land areas
J_2	Natural resident energies on agricultural lands	1.6 x 10^{12} CE Cal/yr	17% of total natural energies based on land areas

Flow	Description	Value	Sources
J_3	Purchased energy inflow	19.3×10^{12} CE Cal/yr	Vol. Co. Econ. Data (1977) — *Services* — \$ 556×10^6; *Food* — \$ 20/wk/ ind x 215,000 = \$ 224×10^6; *Fuels* — elec. — \$ 92.3×10^6, all petroleum fuels — \$ 73.7×10^6, natural and liquid gas — \$ 31.1×10^6; *Purchased Goods* — (Vol. Co. 208 Program Report) — \$ 100×10^6; totaling — $107.7 \times 10^6 \times 13{,}800$ CE Cal/yr = 14.86×10^{12} CE Cal/yr + 10% annual increase (3 yrs) = 19.3×10^{12} CE Cal/yr
J_4	Inflow of tourists	5.5×10^6 people/yr	Greater Daytona Beach Chamber of Commerce (1978)
J_5	New residents	9.7×10^3 people/yr	1980 Census data
J_6	Natural lands converted to urban lands	3.1×10^3 acres/yr	Urban acres — 6.7×10^4 + rural acre estimate $0.3 \times 10^4 = 7.0 \times 10^4$ acres for 215,000 people = 0.32 acres/person x 9.7×10^3 new residents/yr = 3.1×10^3 acres/yr
J_7	Amplifier feedback	0.8×10^{12} CE Cal/yr	Assume 1/3 of gross primary productivity
J_8	Gross primary production (metabolism)	2.3×10^{12} CE Cal/yr	Table 1.
J_9	Degraded sunlight energy and plant metabolism	6.0×10^{12} CE Cal/yr	Difference between inputs and gross primary productivity
J_{10}	Plant structure depreciation	1.4×10^{12} CE Cal/yr	Assume 2% of total stock
J_{11}	Natural structure harvested by man	0.02×10^{12} CE Cal/yr	Vol. Co. 208 Program Report — Total natural and planted pine forests — \$ 1.5×10^6/yr (75% of pine forests are natural) = \$ $1.13 \times 10^6 \times 13{,}800$ CE Cal/yr = 0.02×10^{12} CE Cal/yr
J_{12}	Abandoned agricultural lands returned to natural lands	0.5×10^2 acres/yr	Volusia County Agric. Center
J_{13}	Natural lands converted to agricultural lands	2.0×10^2 acres/yr	Volusia County Agric. Center

Flow	Description	Value	Sources
J_{14}	Agricultural lands converted to urban developed lands	1.0×10^3 acres/yr	Volusia County Agric. Center
J_{15}	Amplifier feedback	0.19×10^{12} CE Cal/yr	Assume 1/3 of gross primary productivity
J_{16a}	Gross primary production of agricultural lands	0.59×10^{12} CE Cal/yr	Table 1.
J_{16b}	Agricultural yield	0.41×10^{12} CE Cal/yr	Pasture – 32,527 acres x \$ 63 sales value/acre* = \$ 2.05×10^6; Veg. Crops – 4,056 acres x \$1546 sales value/acre* = \$ 2.62×10^6; Ferneries – 2400 acres x \$ 5,000/acre† = \$ 12.0×10^6; totaling \$ 22.9×10^6 x 13,800 CE Cal/yr = 0.32×10^{12} + 10% annual increase (3 yrs) = 0.41×10^{12} CE Cal/yr * Brown, 1976 † Johnston, 1977
J_{17a}	Degraded sunlight energy and plant metabolism	0.8×10^{12} CE Cal/yr	Difference between inputs and sum of yield and GPP
J_{17b}	Plant depreciation	0.17×10^{12} CE Cal/yr	Assume 2% of standing crop
J_{18}	Death of population	755 people/yr	Volusia County Dept. of Health
J_{19}	Gross production of urban sector	20.8×10^{12} CE Cal/yr	GPP = $24.9 \times 10^{12} - 3.5 \times 10^{12}$ (govt) – 0.6×10^{12} (agric) = 20.8×10^{12} CE Cal/yr
J_{20}	Export of goods	0.14×10^{12} CE Cal/yr	Sum of manufactured and lumber products – \$ $6 \times 10^6 + 1.5 \times 10^6$ = \$ $7.5 \times 10^6 \times 13{,}800$ CE Cal/yr = 1.04×10^{11} CE Cal/yr + 10% annual increase (3 yrs) = 0.14×10^{12} CE Cal/yr
J_{21}	Energies used for transportation in and operation of urban sector	2.86×10^{12} CE Cal/yr	Gasoline and diesel fuels sales in Vol. Co. – 1977 – 2.2×10^{12} + 10% annual increase (3 yrs) = 2.86×10^{12} CE Cal/yr
J^{22}	Fossil fuel based energies used by agricultural sector	0.22×10^{12} CE Cal/yr	Pasture – 32,527 acres x fuel cost/ac* – \$ 1.79/ac x 1.0×10^5 CE Cal/yr = 5.8×10^9 CE Cal/yr; Veg. and

Flow	Description	Value	Sources
			Truck Crops — 4,056 acres x \$ 56.5/ac* x 1.0 x 10^5 CE Cal/yr = 2.3 x 10^{10} CE Cal/yr; Citrus — 8,500 acres x \$ 10.16/ac* x 1.0 x 10^5 CE Cal/yr = 8.6 x 10^9 CE Cal/yr; Ferneries — 2400 ac x \$ 534/ac† x 1.0 x 10^5 CE Cal/yr = 1.3 x 10^{11} CE Cal/yr; totaling 1.67 x 10^{11} + 10% annual increase (3 yrs) = 2.2 x 10^{11} CE Cal/yr
			* Brown, 1976 † Johnston, 1977
J_{23}	Depreciation of urban structure	1.71 x 10^{12} CE Cal/yr	2% of total stock
J_{24}	Fossil fuel based energies used by government sector	1.9 x 10^{12} CE Cal/yr	Assume 1% of total fossil fuel energies
J_{25}	Energy value of government structure	0.88 x 10^{12} CE Cal/yr	Assume 25% of gross input to government
J_{26}	Depreciation of government structure	0.24 x 10^{12} CE Cal/yr	Assume 2% of total stock
J_{27}	Outflow of tourists	5.5 x 10^6 people/yr	Equal to inflow J_4
J_{28}	Transformation loss of fossil fuel energies into heat	10.66 x 10^{12} CE Cal/yr	Gasoline, diesel fuel, no. 2 fuel expended and electricity consumed (4.44 x 10^{12} + 6.22 x 10^{12} = 10.66 x 10^{12} CE Cal/yr

Natural Energy Calculations

1. Sun: average daily solar radiation = 442 Langleys/day = 442 cal/cm²/day

$$\frac{(442\ \mathrm{cal/cm^2/day})(929\ \mathrm{cm^2/ft^2})(43{,}560\ \mathrm{ft^2/ac})(365\ \mathrm{days/yr})}{1000\ \mathrm{cal/Cal}}$$

$= 6.53 \times 10^9$ Cal/ac/yr

$(6.53 \times 10^9$ Cal/ac/yr$)(77.86 \times 10^4$ land acres $+ 16.32 \times 10^4$ oceanic acres$) = 6.15 \times 10^{15}$ Cal/yr

$(6.15 \times 10^{15}$ Cal/yr$)(7 \times 10^{-4}$ CE Cal$) = 4.31 \times 10^{12}$ CE Cal/yr

2. Chemical potential of rain:

$$\mathrm{CE\ Cal/ac/yr} = \frac{(52\ \mathrm{in/yr})(23\ \mathrm{Cal/gal})(6.27 \times 10^6\ \mathrm{in^2/ac})(0.1\ \mathrm{Ce\ Cal})}{231\ \mathrm{in^3/gal}}$$

$= 3.55 \times 10^6$ CE Cal/ac/yr

$(3.55 \times 10^6$ CE Cal/ac/yr$)(7.786 \times 10^5$ ac$) = 2.76 \times 10^{12}$ CE Cal/yr

3. Tidal energy: Halifax and Indian River estuaries (61.7 mi^2)
and coastal waters (255 mi^2).
$P = \frac{1}{2} pgAh^2n_tc$
p = density of seawater — 1.025 gm/cm^3
g = acceleration of gravity — 980 cm/sec^2
h = average tidal amplitude (NOAA, 1976) — 2.3 ft (70.1 cm)
A = coastal estuary — 61.7 mi^2 = 39,488 ac = 1.6×10^{12} cm^2
coastal oceanic waters — 5 x 51 = 255 mi^2 = 163,200 ac = 6.2×10^{12} cm^2
n_t = number of tides per year — 706
c = number of cycles/tide — 2
P = ½(1.025 gm/cm^3)(980 cm/sec^2)(7.8×10^{12} cm^2)(4914 cm)
(1412 tides)(2.38×10^{-11} Cal/erg) = 6.47×10^{11} Cal/yr
= 6.47×10^{11} Cal/yr x 1.6 CE Cal/yr = 1.04×10^{12} CE Cal/yr
4. Wind:average wind speed of Volusia Co. — 9.2 mph
wind energy/ac/yr = $\frac{\frac{1}{2} mv^2 \text{ (eddy diffusion coefficient)}}{\text{height}}$
= (0.5)(1.2×10^{-3} gm/cm^3)$(406.8\ cm/sec)^2$(10,000 cm^2/sec)
(1/3048 cm)(3.15×10^{13} cm^2)(2.38×10^{-11} Cal/erg)
(3.15×10^7 sec/yr)
= (8.35×10^{12} Cal/yr)(0.13 CE Cal) = 1.0×10^{12} CE Cal/yr
5. Kinetic energy of rain:
PE = mgh = pvgh
PE = (1 gm/cm^2)(6.27×10^6 in/ac)(980 cm/sec^2)(ft elev.)
(30.48 cm/ft)(16.39 cm^3/in^3)(52 in rainfall/yr)
(2.39×10^{-11} Cal/erg)
= 73.36 (in/yr rain)(ft elev. for 4 terraces)(1.17 Cal of PE)
= 73.36 (52 in)(10 ft Silver Bluff terrace)(1.17 CE Cal)
(97,000 ac) = 4.33×10^9 CE Cal/yr
+ 73.36 (52 in)(25 ft Pamlico terrace)(1.17 CE Cal of PE)
(230,000 ac) = 2.57×10^{10} CE Cal/yr
+ 73.36 (52 in)(40 ft Talbot terrace)(1.17 CE Cal)
(345,000 ac) = 6.16×10^{10} CE Cal/yr
+ 73.36 (52 in)(70 ft Penholoway terrace)(1.17 CE Cal)
(90,000 ac) = 2.81×10^{10} CE Cal/yr
= 0.12×10^{12} CE Cal/yr
6. Waves: average wave height — 2.1 ft
Power/length of wave front = $1/8p\ g^{3/2}\ H^{5/2}$
p = density of sea water — 1.025 gm/cm^3
g = acceleration due to gravity — $(980\ cm/sec)^{3/2}$
H = average wave height — 2.1 ft x 30.48 cm/ft = $(64.0\ cm)^{5/2}$
Wave energy/m/yr = 1/8 (1.025 gm/cm^3)$(980\ cm/sec)^{3/2}$
$(64\ cm)^{5/2}$ (2.38×10^{-11} Cal/erg)(3.15×10^7 sec/yr)
(100 cm/m)(8.25 ft/ac x 0.3048 m/ft)(51 mi coast x
640 ac/mi^2) = 7.93×10^{11} Cal/yr
= 7.93×10^{11} Cal/yr x 0.2 CE Cal = 1.59×10^{11} CE Cal/yr
7. Kinetic energy of St. Johns River flow: elev. drop of
11.43 ft over 76.2 mi length
$P = \frac{1}{2} pghv$
½ (1.0 gm/cm^3)(980 cm/sec^2)(11.43 ft x 30.48 cm)
(3,285 av cfs x 28,316.8 cm^3 x 31,536 sec/yr) =
5.0×10^{20} cm/yr
= 5.0×10^{20} cm/yr x 2.38×10^{-11} Cal/erg =
1.19×10^{10} Cal/yr x 1.7 CE Cal = 2.02×10^{10} CE Cal/yr

8. Total Natural Energies:
Sun — 4.31×10^{12} CE Cal/yr
Chemical potential of rain — 2.76×10^{12} CE Cal/yr
Tidal energy — 1.04×10^{12} CE Cal/yr
Wind — 1.00×10^{12} CE Cal/yr
Kinetic energy of rain — 0.12×10^{12} CE Cal/yr
Waves — 0.16×10^{12} CE Cal/yr
Kinetic energy of river — 0.02×10^{12} CE Cal/yr
9.41×10^{12} CE Cal/yr

Biological Sciences

BENTHIC RESTING CYSTS OF *GONYAULAX MONILATA* HOWELL AND THEIR RELATIONSHIP TO RED TIDES IN THE INDIAN RIVER, FLORIDA

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ABSTRACT: Gonyaulax monilata *cysts were found in the sediments from 13 of 37 stations sampled in the Indian River, Florida. The distribution of cysts appears to be the result of 2 unrelated phenomena. In areas where blooms have occurred in the past, the lack of circulation in the lagoon allows the cysts to accumulate. South of Turkey Creek, cysts are found associated with shellfish beds where no blooms have been reported. It is suggested these cysts have been introduced into shellfish regions with oysters which are annually rafted from areas where* G. monilata *blooms occur. Blooms of this toxic dinoflagellate can be expected to reoccur in regions they have in the past, and the possibility of blooms in the vicinity of the shellfish beds around Grant, Florida now exists. However, there is not sufficient evidence to implicate direct toxicity to shellfish by* G. monilata.

HIRANO (1967) and Prakash (1967) independently suggested the possibility that the similar year to year timing and location of dinoflagellate blooms are related to benthic resting cysts (hypnocysts). Several authors (e.g., Steidinger, 1973, 1975a, b; Wall, 1975; Dale, 1977; Anderson and Wall, 1978; Anderson and Morel, 1979a, b; Haddad and Carder, 1979; Anderson, 1980) have advanced the hypothesis that blooms might be initiated by benthic resting cysts. Steidinger (1975a) suggested that localized areas of accumulation of benthic resting cysts act as seed "beds" and that such should be delimited in order to pinpoint origin of blooms.

The Indian River is a shallow lagoonal system on the east coast of Florida separated from the Atlantic Ocean by barrier islands. Periodic blooms in this lagoon are caused by the catenate dinoflagellate *Gonyaulax monilata* Howell (1953). Walker and Steidinger (1979) observed cyst formation in *G. monilata* under laboratory conditions in nitrogen-deficient medium and in stationary cultures. Similar cysts were first tentatively identified in Indian River samples and then conclusively identified by excystment of cysts from

Tampa Bay sediments (Walker and Steidinger, 1979). Following initial identification of *G. monilata* cysts from the Indian River, the sediments of the lagoon in south Brevard County were sampled to determine the distribution and density of this type of cyst. Our results indicate the cyst distribution is determined by the areas of past *G. monilata* blooms, the circulation patterns found in the lagoonal system, and the activity of commercial shell fishermen who regularly relay (transplant) oysters from areas closed to harvesting in the Banana and Indian rivers to lease areas in the Indian River.

METHODS—Between 3 February and 17 April, 1979 grab samples were taken at 37 stations in the Indian River between the Pineda Causeway and Sebastian Inlet (Fig. 1). Fifteen stations are common to those periodically sampled by the Brevard County Health Department (B.C.H.D.); thus, some historical hydrographic and biological data are available. The remaining stations were selected for their proximity to tributaries, shellfish beds, or areas where discolored water has been observed in the past.

Using a Ponar grab, 2 sediment samples were taken at each station. From the first, approximately 300 g of sediment to be used for grain size analysis were placed in a 470 ml jar. The second sample was placed in a 19 l plastic

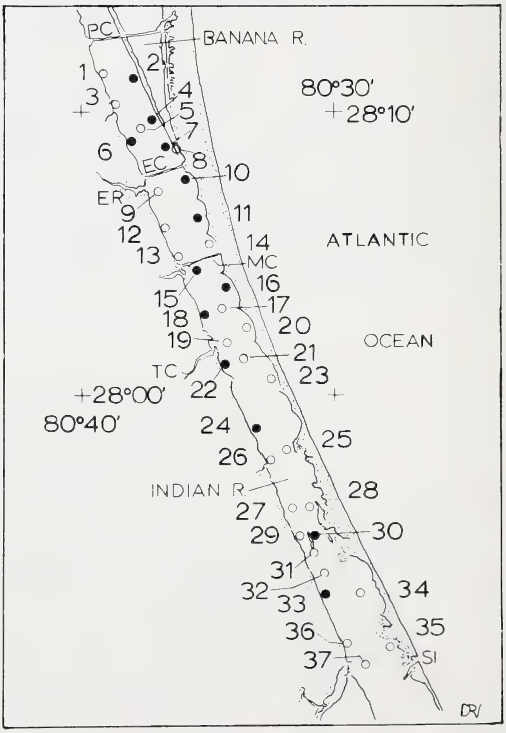

FIG. 1. Geographical distribution of *Gonyaulax monilata* benthic cysts, filled circles, in the Indian River, Florida. Open circles denote no *G. monilata* cysts found in sample. EC, Eau Gallie Causeway; ER, Eau Gallie River; MC, Melbourne Causeway; PC, Pineda Causeway; SI, Sebastian Inlet; TC, Turkey Creek. Grant is just west of Station 29.

bucket which was then filled with water from the collection site for transport to the laboratory. The volume of the sediment sample was determined after settling. By comparing this volume with the area of the mouth of the grab (21.6 cm x 23.5 cm) in the open position and assuming it sampled a uniform depth upon closing, the depth of the grab penetrated into the sediment at each station was calculated.

Samples in the jars were oven dried and subjected to the sieve analysis technique outlined in Lambe (1951). Sieve analysis data were used in an attempt to relate the distribution of *G. monilata* cysts to the depositional environment of the area.

Samples in the bucket were sieved to concentrate the cysts and remove all particulates that did not fall between 20 μm and 90 μm. The concentrated samples were stored in the dark at 7°C until examined; a minimum of three, 0.1 ml subsamples were examined at 100 x magnification for *G. monilata* cysts on a counting slide (Palmer and Maloney, 1954). Additional subsamples (2 to 3 from Stations 15 and 16 and as many as 10 from each of the other 22 stations where no cysts were observed) were analyzed to verify our initial findings. Thus, over 1 ml of concentrated sample from most stations was examined. The results of this effort did not alter the findings of the initial 3 subsamples as reported below. Our results are reported simply as cysts present or absent. Due to agitation of the sediments by wind, boating activity, and bioturbation, we feel any cysts in at least the upper 1 cm would be capable of excysting and thus releasing a motile cell into the water column. Cysts as deep as 10-15 cm may be important as seed populations (Anderson, pers. comm.).

A few cysts were isolated into enriched lagoonal water to check their viability and if possible their identification. Only 2 of 10 cysts excysted after 5 da, neither survived to a recognizable motile stage. However, because the cysts counted in this study had the same general appearance, we assumed they were all viable *G. monilata* cysts. Walker and Steidinger (1979) described *G. monilata* cysts, their Fig. 21 is representative of the cysts from Indian River sediments.

RESULTS—Each station was sampled once during the 10 wk sampling period; depth at the stations ranged 0.6-5.3m. Water temperature ranged from 14.2°C on 10 February to 25.0°C during the second week of April. Salinity ranged from low (ca. 20‰) winter values during February and early March to the high (ca. 34‰) values of late March and April (Owen, 1979).

The sediment types encountered in the Indian River ranged from poorly-sorted sediments with large percentages of particles in the pebble, granule, very coarse sand, coarse sand and medium sand sizes to well-sorted sediments made up almost exclusively of medium or fine sands (Table 1). There appeared to be no definite relationship between the cyst distribution and the type of sediments found.

Gonyaulax monilata cysts were seen in the sediments from 13 of 37 sta-

Table 1. Indian River stations with *G. monilata* cysts and their sediment descriptions. The depth of grab is the grab penetration into the sediments assuming it samples a uniform depth upon closing (revised from Owen, 1979).

Station	Water Depth (m)	Depth of grab (cm)	Sediment Description
2	1.7	2.9	poorly sorted, coarse to fine sands
4	1.3	2.4	poorly sorted, coarse to medium sands
6	2.0	5.3	poorly sorted, medium to fine sands
7	2.0	2.4	poorly sorted, very coarse to medium sands
10	1.0	3.1	well sorted, medium sands
11	1.1	2.8	well sorted, medium sands
15	4.0	4.6	poorly sorted, very coarse to fine sands
16	2.0	2.2	poorly sorted, coarse to fine sands
18	0.8	1.6	well sorted, medium sands
22	0.6	5.2	well sorted, medium sands
24	2.0	3.3	well sorted, medium sands
30	1.1	1.7	well sorted, fine sands
33	1.6	2.5	well sorted, medium sands

tions (Fig. 1, Table 1), most regularly on the east side of the Indian River between the Pineda and Melbourne causeways. In this section, they were found at all the eastern sites except Station 14. South of the Melbourne Causeway, cysts were found at only 7 of 23 stations; 4 on the western and 1 on the eastern side of the lagoon, 1 (Station 15) adjacent to the intra-coastal waterway, and 1 (Station 30) just east of Grant Island.

Discussion—Advection in the Indian River is little more than a sloshing back and forth in the individual basins with a restricted mixing between adjacent basins due to causeways. Also, areas within a given basin, formed by sand bars and spoil islands, are essentially isolated from the general circulation pattern (Trees, 1977). This limited advection, both within and between basins, in large part accounts for the spatial distribution of benthic *G. monilata* cysts.

Blooms of this toxic dinoflagellate have been reported in the Indian River between the Pineda and Eau Gallie causeways, between the Eau Gallie and Melbourne causeways, and the basin just south of the Melbourne Causeway (B.C.H.D., unpublished data; Modert, 1977; Trees, 1977). Like those of the Galveston, Texas area (Wardel et al., 1975), these blooms usually occurred in July and August (sometimes September) when the water temperature rose above 29°C and the salinity was over 32‰. Of the 13 sites where *G. monilata* cysts were found, 9 are within the areas where blooms have developed in the past (Stations 2, 4, 6, 7, 10, 11, 15, 16, 18). Stations 2, 4, 6 and 7 are in the general area where fish kills were recorded by the B.C.H.D. during the summers of 1973, 1975, and 1978 (Ray Grizzle, pers. comm.). Though no specific identifications or cell counts were made during these fish kills, dinoflagellates were present in high numbers in red water areas which had moderate dissolved oxygen concentrations (≥ 3 ppm). Streaks of "white" and green water with lower dissolved oxygen (sometimes < 1 ppm) were also present. Unfortunately, the B.C.H.D. saw no evidence of whether the fish were actually killed in the red water or the low oxygen areas.

The bloom reported by Trees (1977), which formed between the Eau Gallie and Melbourne causeways, provides some evidence supporting the assertion that the cysts remain in the area of the outbreak. The bloom was first seen at the end of June 1977 with concentrations between, 4,000 and 30,000 cells $\bullet l^{-1}$. Concentrations of *G. monilata* in this area increased steadily during early July and on the last sample date (July 12) had reached between 1×10^5 and 8.9×10^5 cells $\bullet l^{-1}$. The bloom occurred in the northern and central areas of the basin that included Stations 9, 10, and 11, of this study. Benthic cysts were found at Stations 10 and 11, (Fig. 1, Table 1), none was seen at Station 9 probably because sediment deposition from the Eau Gallie River has buried them. Cysts were not found in the sediments collected at stations (i.e., 12, 13, and 14) in this basin which were not affected by the 1977 bloom. The restricted water movement that allowed the bloom to remain in the northern portion of the basin also accounts for the presence of the cysts in the sediments of the area. The hypnozygotes or cysts were able to settle out of the water column before they could be transported any great distance.

Perhaps similar to that described for tide pools in Tokyo Bay (Hirano, 1967) or more recently for salt ponds in Cape Cod (Anderson and Wall, 1978; Anderson and Morel, 1979a, b), the method of bloom development in the Indian River can be understood in terms of the weak circulation and the distribution of cysts in the sediments. The first *G. monilata* red tide was recorded in 1951 in the Indian and (adjacent) Banana rivers (Howell, 1953). After 30 yr, blooms of this dinoflagellate still occur when conditions become optimal. Walker and Steidinger (1979) proposed that cysts in Florida waters act as seed beds to initiate *G. monilata* blooms. The density of benthic cysts in the Indian and Banana rivers can apparently provide the 4,000 to 6,000 motile cells $\bullet l^{-1}$ of water that are commonly seen in the initial stages of a bloom. After excystment, the dinoflagellates reproduce asexually and the bloom continues to grow for as long as conditions can support it. Because there is only very weak, limited water circulation and the wind has no major affect on the advection of the water and associated dissolved and/or suspended matter (Trees, 1977; Meyer, 1977), the dinoflagellates remain and become concentrated in limited areas. As is generally believed when conditions become unfavorable, cysts form and accumulate in the sediments serving as seeds for future outbreaks.

In addition, there appears to be no background level of motile cells in this lagoon; thus the cysts are apparently the only source for the seed population of *G. monilata* blooms. David (1978) did not find motile *G. monilata* cells in a 6-mo study covering the area south of the Pineda Causeway to just south of the Melbourne Causeway. This apparent lack of motile cells of bloom species in the plankton for periods of months was also reported by Hirano (1967).

In the southern part of the study area where there are no records of past *G. monilata* blooms, *G. monilata* cysts were found at 4 sites, Stations 22, 24, 30 and 33 (Fig. 1). The latter 3 sites are in areas leased to commercial shell fishermen. Although these are in regions which appear to lack the widespread distribution of cysts that occur in the bloom areas to the north, localized blooms are possible in them. This is especially true at Stations 24 and 33 because of an apparent restricted water circulation. The areas around both sites are separated from the rest of the basin by a series of spoil islands and sand bars (K.C.O., pers. obser.). Such lack of water circulation might allow *G. monilata* to reach concentrations that are toxic to fish (Gates and Wilson, 1960; Ray and Aldrich, 1967; Sievers, 1969) and to a number of invertebrates including *Crassostrea virginica*, the American oyster (Sievers, 1969).

Field observations have provided conflicting reports of the effects of *G. monilata* blooms on *Crassostrea virginica*. Wardle et al. (1975) reported no effects on *C. virginica* during a 1971 bloom (1.2×10^6 cells $\bullet l^{-1}$) while there was "common" occurrence of "moribund" *C. virginica* during a 1972 bloom (1.88×10^6 cells $\bullet l^{-1}$) along the beachfront at Galveston, Texas. Walker (unpubl. data) found no shellfish mortality during a *G. monilata* bloom (5.7×10^6 cells $\bullet l^{-1}$) in August 1979 in Pensacola Bay, Florida. Also, no mortalities of marine organisms were observed associated with the bloom (maximum cell count of 1.65×10^7 cells $\bullet l^{-1}$) in Mississippi waters in August 1979 (Perry et al., 1979). Thus, there is not sufficient field evidence to implicate direct toxicity due to *G. monilata* blooms. *G. monilata* is not a causative agent of paralytic shellfish poisoning.

The presence of cysts in such close association with the shellfish beds around Grant appears to be more than just coincidental. For several years, shellfishermen have been relaying large quantities of oysters from the Banana River and sections of the Indian River north of the Eau Gallie Causeway to their lease areas near Grant (Capt. Henry Morgan, Florida Marine Patrol, pers. comm.). Because red tides caused by *G. monilata* blooms are known to occur in areas from which oysters are transplanted, it is reasonable to assume that oysters rafted to the leases have had *G. monilata* cysts associated with them. Thus, they would be introduced into these areas in the same manner as has been suggested for the colonization of new regions in Cape Cod, Massachusetts by *G. tamarensis* (Anderson and Wall, 1978). We emphasize that *G. monilata* has not been associated with shellfish toxicity to humans.

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LATE PLEISTOCENE FORAMINIFERA, FLORIDA KEYS

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Abstract: *Fossil foraminifera have been identified from the late Pleistocene Miami Limestone and Key Largo Limestone of the Florida Keys. The dominant foraminifera from the oölite unit of the Miami Limestone are the same species that occur most commonly in the recent oölite deposits of the Great Bahama Bank. The assemblage from the bryozoan unit of the Miami Limestone is typical of the shallow shelf sea behind the Cat Cay oölite mounds today on the western edge of the Bahama Banks. The foraminifera of the upper part of the Key Largo Limestone suggest a shallow-water, coral reef deposit in the absence of a protective outer reef.*

Benthic Foraminifera are significant both as biotic elements of faunas and as skeletal constituents of sediments in shallow-water, carbonate depositional environments. The tests of foraminifera may be preserved as microfossils in limestones deposited in such environments, and these fossils provide significant clues as to the original environment of deposition.

The bedrock of the Upper Florida Keys, from Soldier Key to the north through the Newfound Harbor Keys to the southwest, is the late Pleistocene Key Largo Limestone, a coral reef deposit. The bedrock of the Lower Keys, from Big Pine Key to Key West, is the oölite unit of the Miami Limestone, which is contemporaneous with the upper portion of the Key Largo. The bryozoan unit of the Miami Limestone apparently interfingers with the oölite unit in the subsurface at some localities in the Lower Keys (Steinker and Floyd, 1975). The microfossils of these units have not previously been studied.

Fossil foraminifera have been recovered from the upper part of the Key Largo Limestone at Windley Key, Plantation Key, Grassy Key, and Vaca Key; from the oölite unit of the Miami Limestone at Big Pine Key, Little Torch Key, No Name Key, Rockland Key, and Stock Island; and from the bryozoan unit of the Miami Limestone at No Name Key. Except for the samples from Windley Key Quarry where the Key Largo Limestone is exposed in the quarry walls, all samples were from dredged materials.

I characterize the foraminiferal faunas represented in these samples, compare them with foraminiferal faunas from analogous modern depositional environments, and draw inferences concerning the environments of deposition of the rock units under consideration.

Methods—The rock samples were disaggregated by crushing and soaking in water. The disaggregated material was washed and sieved, using U.S. Standard Sieves with openings of 1.19 and 0.125 mm. Foraminifera then were picked from the residues using a dissecting microscope.

Previous work — Hoffmeister, Stockman, and Multer (1967) proposed the term Miami Limestone to include a lower bryozoan unit and an upper oölite unit. They suggested that similar deposits are being produced today on the western edge of the Great Bahama Bank where colonies of the cheilostome bryozoan *Schizoporella floridana* Osburn are growing in the shallow lagoon to the east of a large underwater mound of unstable oölite, which occurs near the edge of the shelf.

The Key Largo Limestone of the Upper Florida Keys is a coral reef deposit consisting mainly of an *in situ* framework of hermatypic corals and interstitial calcarenite. Various interpretations have been suggested for the environment of deposition of this unit. According to Stanley (1966), head corals were the major frame-builders of the Key Largo coral reef, and *Acropora palmata*, the principal framework builder of the modern outer reefs of south Florida (Shinn, 1963), is absent from the Key Largo Limestone of the Keys. Stanley (1966) noted the resemblance of the Key Largo fauna to that of modern patch reefs of the back-reef environment and to that of the deeper-water *Montastrea annularis* zone of living bank reefs near the edge of the shelf, but preferred the interpretation that the Key Largo represents the deep-water *Montastrea annularis* zone of a bank reef.

Hoffmeister and Multer (1968) believed that the Key Largo Limestone of the Upper Keys originated during Sangamon time as a coalescing series of patch reefs in the back-reef environment, which was bordered by an outer reef along the seaward edge of the platform. Their interpretation was based partially upon the absence of *Acropora palmata* and the presence of a typical patch reef coral fauna in the Key Largo and the presence of *Acropora palmata* in the Key Largo underlying the recent outer reef.

Enos and Perkins (1977) re-evaluated Quaternary sedimentation patterns in south Florida. Perkins (*in* Enos and Perkins, 1977) recognized 5 Pleistocene marine units (Q1 through Q5), separated by discontinuity surfaces representing low stands of sea level. The coralline Key Largo Limestone includes units Q3, Q4, and Q5. Dates for these units are based upon the work of Mitterer (1975): Q5 — 134,000 B.P., Q4 — 180,000 B.P., and Q3 — 236,000 B.P. Coral reefs first appeared in the area during Q3 time and persisted during Q4 and Q5 time. (All of my Key Largo samples are from units Q4 and Q5.) In Q4 and Q5 time colonies of *Montastrea* and *Diploria* constructed reefs in the area of the present Keys, and the bryozoan *Schizoporella floridana* grew on the shallow marine platform behind the reefs. During Q5 time, an oölite mound formed in the area of the Lower Keys. Perkins postulated that as sea level rose at this time a sand-shoal — patch-reef complex migrated landward to the position now occupied by the Keys. According to Perkins (*in* Enos and Perkins, 1977, p. 179), the "maximum water depth over the frontal edge of this transgressive coral-rich unit probably never exceeded 10 ft (3 m)." He notes (p. 183) that this model "does not require a seaward reef barrier for its inception." Furthermore, Enos (*in* Enos and Perkins, 1977, p. 114) noted that if present sea level "continued to rise until the Florida Keys were flooded, the position of the outer reef might shift to the Florida Keys." The absence of *Acropora palmata* from the coral rock of the Keys might be attributed to reef growth on the inner shelf, away from maximum wave action; and the deeper water at the shelf edge may have been unfavorable for reef growth.

There have been few publications on later Cenozoic foraminifera from south Florida. Cole (1931) described some Pliocene and Pleistocene foraminifers from the Caloosahatchee, Fort Thompson, and Anastasia formations. Schroeder and Bishop (1953) published a note on Plio-Pleistocene assemblages from Lee and Charlotte counties. And Conklin (1968) used foraminiferal assemblages to interpret the environments of deposition of the Caloosahatchee, Fort Thompson, and Coffee Mill Hammock formations in the Caloosahatchee River area.

RESULTS — Most of the samples examined were found to contain very few foraminifera, most apparently having undergone dissolution subsequent to deposition. Most samples from the Miami oölite were almost barren of foraminifera, except for rare specimens of *Archaias angulatus*, *Asterigerina carinata*, and *Rotalia rosea*, all of which have thick test walls. However, a few oölite samples from Cudjoe Key contained a good deal of broken shell material, and foraminifera were somewhat more numerous and diverse than in the samples of nonshelly oölite. Foraminifera identified from the shelly oölite include *Archaias angulatus*, *Asterigerina carinata*, *Quinqueloculina lamarckiana*, *Q. seminulum*, and *Elphidium* sp., all in low numbers and mostly well weathered or abraded.

Dredged samples of bryozoan limestone were collected at several localities along the north side of the Lower Keys. These samples contained massive colonies of the bryozoan *Schizoporella floridana* and are considered to belong to the bryozoan unit of the Miami Limestone. A sample from No Name Key was found to contain more numerous and a more diverse assemblage of foraminifera than in the oölite, including the following species, listed in order of relative abundance (percentages given in parentheses).

Ammonia beccarii tepida (27%)
Archaias angulatus (22%)
Rosalina bahamaensis (16%)
Asterigerina carinata (11%)
Quinqueloculina poeyana (7%)
Q. agglutinans (4%)
Triloculina linneiana (4%)
T. carinata (1%)
Articulina lineata (1%)
A. mucronata (1%)
Bolivina pulchella primitiva (1%)
Nonion grateloupi (1%)
Elphidium morenoi (1%)
E. poeyanum (1%)
E. sagrum (1%)
Cymbaloporetta squammosa (1%)

Samples of the Key Largo limestone were collected from several localities in the Upper Keys. All were from Perkins' (*in* Enos and Perkins, 1977) units Q4 and Q5. In some samples, especially those from the lower unit Q4, most of the foraminiferan tests apparently had been leached out. Perkins noted that leaching of fossil fragments has been more extensive in unit Q4 than in unit Q5. So far, 46 species of foraminifera have been recognized from the Key Largo Limestone of the Upper Keys. These species are indicated by a C in the faunal list at the end of this paper. All are still living in the south Florida region today.

Among the samples from the Key Largo Limestone, foraminifera are best represented in samples from the upper part of the Key Largo (Perkins' unit Q5) on Plantation Key. Thirty-nine species were identified among 300 specimens picked from samples taken at this locality. These are listed below in general order of decreasing abundance.

Rotalia rosea (14%)
Archaias angulatus (10%)
Amphistegina lessonii (8%)
Rosalina bahamaensis (7%)
Discorinopsis aguayoi (6%)
Miliolinella circularis (5%)
Cibicides lobatulus (5%)
Asterigerina carinata (4%)
Quinqueloculina bosciana (3%)
Q. poeyana (3%)
Elphidium poeyanum (3%)
E. articulatum (3%)
Discorbis mira (3%)
Triloculina bassensis (2%)
Elphidium advenum (2%)
Eponides repandus (2%)
Neoconorbina orbicularis (2%)
Quinqueloculina lamarckiana (2%)
Elphidium sagrum (1%)
Cibicides refulgens (1%)
Peneroplis proteus (1%)
Elphidium discoidale (1%)
Eponides antillarum (1%)
Quinqueloculina seminulum (1%)
Q. tenagos (1%)
Nonion grateloupi (1%)
Ammonia beccarii (1%)
Rosalina floridana (1%)
Cymbaloporetta squammosa (1%)
Hauerina bradyi (0.5%)
Spiroloculina antillarum angulata (0.5%)
Quinqueloculina bradyana (0.5%)
Triloculina linneiana (0.5%)
Quinqueloculina subpoeyana (0.5%)
Q. bidentata (0.5%)
Bolivina rhomboidales (0.5%)
B. lowmani (0.5%)
Nonion sp. (0.5%)
Siphonina pulchra (0.5%)

DISCUSSION—The foraminiferal assemblages from the late Pleistocene rock units of the Florida Keys were compared with assemblages from areas in south Florida and the Bahamas that are thought to represent modern analogs for the paleodepositional environments. Whereas living populations of foraminifera seem to be more common on marine vegetation than among bottom sediments in tropical, shallow-water, carbonate depositional environments (see, for example, Steinker 1977, p. 55-56), it is the tests of dead individuals among the bottom sediments that eventually may become incorporated into the stratigraphic record. Therefore, the fossil assemblages were compared with thanatocoenoses from modern sediment samples rather than with biocoenoses from marine vegetation.

The foraminiferal assemblage from the Miami oölite of the Lower Keys was compared with assemblages obtained from samples collected at the Cat Cay and Joulter's Cay oölite mounds on the Great Bahama Bank. As with the Miami oölite, foraminifera are generally rare among the modern deposits and the most commonly encountered species are the thick-walled *Archais angulatus*, *Asterigerina carinata*, and *Rotalia rosea*. In addition to these 3 species, a few broken miliolids were found at the Cat Cay locality and rare specimens of *Articulina mucronata*, *Quinqueloculina seminulum*, *Triloculina carinata*, and *Rosalina bahamaensis* were found at Joulter's Cay. *Archaias angulatus* is nearly ubiquitous throughout the south Florida and Great Bahama Bank regions. *Asterigerina carinata* seems to be characteristic of an exposed, turbulent, shelf-edge type of environment (Todd and Low, 1971; Weis and Steinker, 1977), such as might be expected in the vicinity of an oölite bank. It is doubtful that the foraminifera typically live among the wave-agitated ooids where there is little vegetation; instead, they probably represent an allochthonous assemblage derived from the seaward side of the oölite mounds.

The fossil foraminiferal assemblage from the bryozoan unit of the Miami Limestone closely resembles the modern Florida Bay fauna described by Bock (1971), except for the presence in the bryozoan limestone of *Asterigerina carinata*, which is typical of a shelf-edge or outer-reef type of environment (Todd and Low, 1971; Weis and Steinker, 1977). Hoffmeister, Stockman, and Multer (1967) suggested that the shallow lagoon just east of the Cat Cay oölite mound on the western side of the Great Bahama Bank represents the type of environment in which the bryozoan unit formed. Todd and Low (1971) studied the modern foraminiferal fauna from the Bahama Bank west of Andros Island. The foraminiferal assemblage they described from the shelf lagoon just east of South Riding Rock in a water depth of 6 m (their station A3) includes all of the more common species that I found in the bryozoan unit, suggesting similar environments. And the presence of *Asterigerina carinata* suggests a proximity to a more wave-exposed environment.

As noted previously, although the Key Largo Limestone represents a Pleistocene coral reef deposit, the type of reef and the environment of deposition have been variously interpreted. Stanley (1966, p. 1933) noted that "the molluscan and foraminiferal faunas are not especially useful for solving these problems because studies of Recent assemblages of these groups . . . have not yielded sufficiently detailed information for such minor discriminations to be made." However, more recently Weis and Steinker (1977) studied the foraminiferal assemblages associated with the more protected, nearshore patch reefs and with the more wave-exposed outer reef at the edge of the shelf off Big Pine Key and found (p. 95) that "although the two faunas have many species in common, they can be distinguished on the basis of the general assemblage of species present and the proportions in which they occur." The results reported by Weis and Steinker (1977) provide a basis for the interpretation of the environment of deposition of the upper part of the Key Largo Limestone of the Upper Keys, based on foraminiferal assemblages. It should be noted, however, that this interpretation is based on a limited number of rock samples, some of which contain very few microfossils.

Weis and Steinker (1977, p. 93, Table 5) summarized some of the diagnostic differences between south Florida outer reef and patch reef foraminiferal assemblages, based on their study of the reefs off Big Pine Key. All of their samples were collected from water depths of 10 m or less. Among the outer reef sediments the foraminiferal assemblage tends to be dominated by species with robust tests and the tests commonly are abraded, whereas at the patch reefs the sediments and tests are less well sorted and fragile tests are more common. Among the outer reef sediments *Archaias angulatus* is the most abundant species, comprising approximately 27% of the fauna, whereas among the patch reef sediments *Rotalia rosea* is most common, comprising 14% of the fauna. Other common outer reef species are *Rotalia rosea* (14%), *Peneroplis proteus* (10%), *Amphistegina lessonii* (8%), and *Homotrema rubrum* (7%). Other common patch reef species are *Archaias angulatus* (12%), *Quinqueloculina lamarckiana* (10%), *Q. tricarinata* (8%), *Discorbis mira* (6%), *Peneroplis proteus* (5%), and *Miliolinella circularis* (5%). Weis and Steinker (1977) considered *Articulina mexicana*, *Asterigerina carinata*, *Eponides repandus*, and occasional globigerinids to be characteristic of the outer reef environment. And they considered *Ammonia beccarii parkinsoniana*, *Clavulina tricarinata*, *Elphidium sagrum*, *Peneroplis pertusus*, *Quinqueloculina poeyana*, and *Valvulina oviedoiana* to be characteristic of the patch reef environment. In addition, the Peneroplidae was dominant at the outer reef, the Miliolidae at the patch reefs.

The Key Largo foraminiferal assemblage shows resemblances to both the modern patch reef and outer reef faunas. Of the 15 species recorded by Weis and Steinker (1977) from the patch reefs in frequencies greater than 1%, only *Homotrema rubrum*, *Pyrgo denticulata*, and *Quinqueloculina lamarckiana* have not been found in the Key Largo. And of the 10 species occurring in frequencies greater than 1% among the outer reef sediments, only *Homotrema rubrum* and *Quinqueloculina tricarinata* have not been recovered from Key Largo samples. Of the 46 species so far identified from the upper part of the Key Largo Limestone, the following are particularly typical of the modern outer reef environment of south Florida: *Amphistegina lessonii*, *Asterigerina carinata*, and *Eponides repandus*. Weis and Steinker (1977) found these 3 species to be much more common among the outer reef sediments than among the patch reef sediments, and Rose and Lidz (1977) found them to be restricted to the outer margins of the platform in south Florida. Among the species present in the Key Largo samples, Todd and Low (1971) reported that *Amphistegina lessonii*, *Asterigerina carinata*, *Cibicides lobatulus*, and *Rotalia rosea* are largely restricted to the outer edge of the Bahama Bank west of Andros Island, and Illing (1952) found that *Amphistegina lessonii*, *Eponides antillarum*, *E. repandus*, *Quinqueloculina bradyana*, *Q. lamarckiana*, and *Rotalia rosea* are characteristic of the outer exposed zone of the Bahama Bank. Based on the work of Weis and Steinker (1977), typical patch reef species in the Key Largo fauna include *Discorbis mira*, *Elphidium sagrum*, *Miliolinella circularis*, *Peneroplis pertusus*, *Quinqueloculina bosciana*, and *Q. lamarckiana*. Key Largo species that are common in both modern outer reef and patch reef environments include *Archaias angulatus*, *Peneroplis proteus*, *Rosalina bahamaensis*, *R. floridana*, and *Rotalia rosea*.

This mixture of species typical of the exposed outer reef environment and species typical of the more protected patch reef environment, along with species common to both, suggests an intermediate type of environment. Furthermore, the resemblance of the Key Largo foraminiferal fauna to the modern fauna described by Weis and Steinker (1977) from shallow-water reefs, the absence of deeper-water species, and the absence of pelagic species indicate a shallow-water origin for the Key Largo Limestone of the Upper Keys. These inferences would seem to support the model of Enos and Perkins (1977) for deposition of the upper part of the Key Largo coral rock as a reef complex migrating landward as sea level rose, without a protective outer reef.

The greater abundance of specimens and diversity of species in the samples from the upper part of unit Q5 at Plantation Key than in the samples from other localities allows for more detailed comparisons with the results of Weis and Steinker (1977). *Amphistegina lessonii* comprised 8% and *Asterigerina carinata* comprised 4% of both this fossil assemblage and the modern outer reef assemblage, whereas these species occur in frequencies of less than 1% at the modern patch reefs. *Eponides repandus* is present in low numbers in the Key Largo and at the outer reef, but generally is absent from patch reef samples. On the other hand, *Rotalia rosea* is the most abundant species in the Plantation Key samples and at the patch reefs, comprising 14% of each assemblage. Furthermore, *Ammonia beccarii*, *Discorbis mira*, *Elphidium sagrum*, *Miliolinella circularis*, *Quinqueloculina bosciana*, and *Q. poeyana* occur in low to moderate numbers in both the fossil samples and the patch reef samples, but are rare to absent in the outer reef samples. This again suggests an intermediate type of environment.

However, the Plantation Key fossil assemblage differs from the modern reef assemblages in several ways, perhaps due partially to differential preservation and leaching. Striking differences include the low frequency of *Peneroplis proteus* in the fossil samples (1%), whereas it generally is a conspicuous element of the modern reef faunas, and the apparent absence in the Key Largo of *Homotrema rubrum*, which is found both on the outer reefs and patch reefs today. In the sediment samples from modern outer reefs and patch reefs the superfamily Miliolidea generally accounts for more than 50% of the fauna (Weis and Steinker, 1977). This also is true for most of the Key Largo samples examined, with *Archaias angulatus* usually the dominant species. In contrast, in the fossil samples from Plantation Key the superfamily Rotaliidea makes up more than 65% of the fauna. One conspicuous species of this superfamily at Plantation Key is *Discorinopsis aguayoi*, which Weis and Steinker (1977) did not find among reefal sediments. Rose and Lidz (1977), Todd and Low (1971), Bock (1971), and Steinker (1980a, 1980b, 1981) consider this species to be restricted to very shallow, nearshore conditions. Perkins (*in* Enos and Perkins, 1977) has shown that a protected shelf area was present behind the Key Largo reef tract during Sangamon time, and Bain and Teeter (1975) have reported a storm accumulation of typical Florida Bay molluscans from the upper part of the Key Largo. So perhaps specimens of *Discorinopsis aguayoi* are allochthonous elements transported by storm waves from the back-reef environment.

Summary — Fossil foraminifera have been studied from the late Pleistocene oölite and bryozoan units of the Miami Limestone and the Key Largo Limestone of the Florida Keys. Although specimens generally were scarce in most samples, a few samples yielded sufficient numbers for paleoenvironmental analysis. The thick-shelled *Archaias angulatus*, *Asterigerina carinata*, and *Rotalia rosea* were the most common species from the oölite of the Lower Keys. These 3 species also were the most common foraminifera from samples of the modern oölite mounds at Cat Cay and Joulter's Cay in the Bahamas. *Asterigerina carinata* is characteristic of a shelf-edge type of environment, where *Rotalia rosea* also is common. These species are considered to be allochthonous elements among the oölite deposits.

Samples of bryozoan limestone were collected from dredgings on the north side of the Lower Keys. These contain a more diverse foraminiferal fauna than is present in the oölite unit with sixteen species identified. For the most part, this assemblage is characteristic of the shelf lagoon east of the Cat Cay oölite mounds on the western margin of Great Bahama Bank, which Hoffmeister, Stockman, and Multer (1967) considered to represent a modern analog for the environment of deposition of the bryozoan unit of the Miami Limestone.

Forty-six species of foraminifera were identified from the Key Largo Limestone of the Upper Keys. Foraminifera are more common in unit Q5 than in unit Q4; according to Perkins (*in* Enos and Perkins, 1977) leaching of fossils is more extensive in unit Q4 than in Q5. The best assemblage is from samples of the Q5 unit collected at Plantation Key. Most of the species are typical of modern south Florida coral reefs. Weis and Steinker (1977) discovered diagnostic differences between the foraminiferal faunas of south Florida outer reefs and patch reefs. The Key Largo assemblage includes characteristic outer reef species and patch reef species and seems to be intermediate in nature. This suggests that as sea level rose during the Sangamon interglacial stage, the outer reef migrated landward to the present position of the Florida Keys. Deeper-water foraminifera are not present in the assemblage, which is interpreted to be relatively shallow water in origin (probably less than 10 m). The presence of typical shelf-edge species, such as *Asterigerina carinata* and *Amphistegina lessonii*, suggests the absence of a protective outer reef at this time.

Faunal List

Identified species are listed in alphabetical order. The original name, author, and year of description are cited for each. Indication is made for each species as to whether it occurred in the oölite unit (O), the bryozoan unit (B), or the coralline Key Largo Limestone (C). Major sources used for the species identifications include Cushman (1918-31; 1922), Barker (1960), Bock (1971), Todd and Low (1971), Weis and Steinker (1977), and Steinker (1980b). Poor preservation made many identifications difficult.

Ammonia beccarii parkinsoniana = *Rosalina parkinsoniana* d'Orbigny, 1839. (C)
A. beccarii tepida = *Rotalia beccarii tepida* Cushman, 1931. (B)
Amphistegina lessonii d'Orbigny, 1826. (C)
Archaias angulatus = *Nautilus angulatus* Fichtel and Moll, 1803. (O, B, C)
Articulina lineata Brady, 1884. (B)
A. mucronata = *Vertebralina mucronata* d'Orbigny, 1839. (B)
Asterigerina carinata d'Orbigny, 1839. (O, B, C)
Bolivina lowmani Phleger and Parker, 1951. (C)
B. pulchella primitiva Cushman, 1930. (B)
B. rhomboidales = *Textularia rhomboidalis* Millett, 1899. (C)
Cibicides lobatulus = *Nautilus lobatulus* Walker and Jacob, 1798. (C)
C. refulgens Montfort, 1808. (C)
Cymbaloporetta squammosa = *Rotalia squammosa* d'Orbigny, 1826. (B, C)
Discorbis mira Cushman, 1922. (C)
Discorinopsis aguayoi = *Discorbis aguayoi* Bermudez, 1935. (C)
Elphidium advenum = *Polystomella advena* Cushman, 1922. (C)
E. articulatum = *Polystomella articulatum* d'Orbigny, 1839. (C)
E. discoidale = *Polystomella discoidale* d'Orbigny, 1839. (C)
E. morenoi Bermudez, 1935. (B)
E. poeyanum = *Polystomella poeyana* d'Orbigny, 1839. (B, C)
E. sagrum = *Polystomella sagra* d'Orbigny, 1839. (B, C)
E. tumidum Natland, 1938. (C)
Eponides antillarum = *Rosalina antillarum* d'Orbigny, 1839. (C)
E. repandus = *Nautilus repandus* Fichtel and Moll, 1798. (C)
Hauerina bradyi Cushman, 1917. (C)
Heterostegina depressa d'Orbigny, 1826. (C)
Miliolinella circularis = *Triloculina circularis* Bornemann, 1855. (C)
Neoconorbina orbicularis = *Rosalina orbicularis* Terquem, 1876. (C)
Nonion depressulum matagordanum Kornfeld, 1931. (C)
N. grateloupi = *Nonionina grateloupi* d'Orbigny, 1826. (B, C)
N. sp. (C)

Peneroplis pertusus = *Nautilus pertusus* Forskal, 1775. (C)
P. proteus d'Orbigny, 1839. (C)
Quinqueloculina agglutinans d'Orbigny, 1839. (B)
Q. bidentata d'Orbigny, 1839. (C)
Q. bosciana d'Orbigny, 1839. (C)
Q. bradyana Cushman, 1917. (C)
Q. lamarckiana d'Orbigny, 1839. (O, C)
Q. poeyana d'Orbigny, 1839. (B, C)
Q. polygona d'Orbigny, 1839. (C)
Q. seminulum = *Serpula seminulum* Linnaeus, 1767. (O, C)
Q. subpoeyana Cushman, 1922. (C)
Q. tenagos Parker, 1962. (C)
Rosalina bahamaensis Todd and Low, 1971. (B, C)
R. floridana = *Discorbis floridana* Cushman, 1922. (C)
Rotalia rosea d'Orbigny, 1826. (O, C)
Siphonina pulchra Cushman, 1919. (C)
Spiroloculina antillarum angulata Cushman, 1921. (C)
Triloculina bassensis Parr, 1945. (C)
T. carinata d'Orbigny, 1839. (B)
T. linneiana d'Orbigny, 1839. (B, C)
T. rotunda d'Orbigny, 1826. (C)
Trochammina inflata = *Nautilus inflatus* Montagu, 1808. (C)

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Biological Sciences

OBSERVATIONS OF GULF OF MEXICO STURGEON (*ACIPENSER OXYRHYNCHUS DESOTOI*) IN THE APALACHICOLA RIVER, FLORIDA

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Abstract: *Twelve Gulf of Mexico Sturgeon* (Acipenser oxyrhynchus desotoi) *were observed from the Apalachicola River, Florida, from 1976-1981. Seven were tagged and released with 2 being recaptured by anglers. Dates and water temperature of upriver, prespawning spring migrations along with downriver, postspawning, fall migrations were obtained. One larval sturgeon was captured in the upper Apalachicola River at a temperature of 23.9°C, and a flowing male was observed in the same area at a temperature of 20.6°C. An important sturgeon spawning section of the river has been identified for protection. Angler snagging of sturgeon in the upper Apalachicola River was monitored during 1981, revealing an estimated 35-40 sturgeon (average weight 33-45 kg) harvested. The Gulf of Mexico Sturgeon is currently listed as a threatened species by the Florida Committee on Rare and Endangered Plants and Animals.*

Two subspecies of *Acipenser oxyrhynchus* occur in Florida: *A. o. oxyrhynchus* of the Atlantic Coast and *A. o. desotoi* (Vladykov, 1955) of the Gulf of Mexico. Primary differences between subspecies (Vladykov and Greenly, 1963) are relative head length (longer in Gulf Coast sturgeon), shape of scutes (length shorter than width in Gulf sturgeon; opposite in Atlantic sturgeon), length of pectoral fins (slightly longer in Gulf sturgeon), and probably most significantly length of spleen (16-19% of fork length in Gulf sturgeon; 3-9% in Atlantic sturgeon).

The distribution of *A. o. desotoi* is limited to the eastern Gulf of Mexico. Atlantic sturgeon occur along the Atlantic coast of North America south to Miami, Florida (Vladykov and Greenly, 1963). These subspecies are allopatric, having been separated by the emergence of peninsular Florida and maintained by the thermal barrier of the Gulf Stream around south Florida (Rivas, 1954).

Inasmuch as the problems regarding conservation of the 2 subspecies are the same, they were treated concurrently by the Florida Committee on Rare and Endangered Plants and Animals, which has listed *Acipenser oxyrhynchus* as a threatened species (Gilbert, 1978). It is presently classified by the Florida Game and Fresh Water Fish Commission as a species of special concern.

History — The once large and lucrative Florida sturgeon industry has been reduced to a small fraction of its former importance (Murawski and Pacheco, 1977). The first commercial fishery on the Florida Gulf Coast opened in Tampa Bay in 1886 and operated effectively for 3 yr, until annual catches dropped from around 2,000 to 7 sturgeon (U.S. Commission of Fish and Fisheries, 1902).

The Apalachicola River had a long history of sturgeon fishing. The fishery declined from an average of 9,000-27,000 kg/yr before 1917 to no substantial commercial fishery in recent years (National Marine Fisheries Service, 1977). The U.S. Army Corps of Engineers (1978) stated that the commercial fishery in the Apalachicola River system effectively ended in 1970, when only 5 fish were taken. In 1962 and to the present, a hook-and-line sports fishery has developed below the Jim Woodruff Dam, where the sturgeon are blocked from any further migration upstream.

Study Area — The Apalachicola River basin, which covers an area of 31,200 square km in Florida, Georgia, and Alabama encompasses 4 major river drainages: Flint, Chattahoochee, Chipola and Apalachicola. The Flint and Chattahoochee rivers flow into Lake Seminole, a 15,182 ha reservoir formed following the completion of Jim Woodruff Dam in 1957. These 2 rivers unite at this point to form the Apalachicola River which, with the Chipola, is a major source of fresh water and nutrients for Apalachicola Bay (Livingston, 1974).

The survey outlined in this paper was concentrated on the Apalachicola River, which is 171.1 km long. This river, is the largest on the entire Gulf Coast of Florida (Koefoed and Gorsline, 1963) and in terms of volume, is the largest river in the state. For about 80% of its length, the Apalachicola River, which is bounded by a series of swamps and marshes, has an average flow of 664 m^3/s (U.S. Geological Survey, 1971).

Methods — From 1976 to 1981 sturgeon were captured by sinking monofilament gill nets, trawls, plankton nets, anglers, and by electroshocker during anadromous fish-sampling surveys. We measured the fork length of sturgeon to the nearest millimeter and their weights to the nearest gram where possible (Lagler, 1956). Dorsal, lateral, and ventral scutes were counted on 2 occasions. Pertinent water chemistry data were recorded. All fish except the larva and angler caught were tagged with Floy FD-67 Anchor tags, applied with Dennison "Swiftachment" fastner guns to the dorsal and anal fins.

Results and Discussion — Twelve Gulf of Mexico sturgeon have been observed by project personnel in the Apalachicola River (Table 1), 4 which were angler caught, and 8 obtained through project sampling of which 7 were tagged and released. Two recaptures, both through angler snagging below Jim Woodruff Lock and Dam have been reported to date.

Upper River — Six sturgeon, 1 larval (9.71 mm), 1 juvenile (430 mm) and 4 adults (1,420 mm; 1,500 mm; 1,570 mm; 1,930 mm), were captured by project sampling in the upper Apalachicola River (river km 100 and above) between late April and mid-September from 1976 thru 1980.

The larval sturgeon was captured on 11 May 1977. The water temperature was 23.9°C, and river flow was 365 m^3/s. This is believed to be the first larval individual captured in a Gulf of Mexico drainage river (Wooley et al., 1982). This is extremely important because it indicates that a small, spawning population of sturgeon is still using the Apalachicola River. Because exact spawning times have never been recorded in the literature for sturgeon (Murawski and Pacheco, 1977) the date, water temperature, and flow data are of interest. This specimen has been deposited in the Tennessee Valley Authority Regional Larval Fish Identification and Information Center, Norris, Tennessee. The juvenile captured (14 June 1979) may have been accompanying adults on the spring migration; Huff (1975) found this to be characteristic of the species.

Of the 4 adults captured, 1 (a ripe male taken on 28 April 1980), was observed at a water temperature 20.6°C over a limestone shoal area in about 1.7 m of water at river km 168.8. Inasmuch as Dees (1961), Vladykov and Greeley (1963) and Huff (1975) reported that sturgeon spawn over a hard bottom in areas of shallow, running water, shoal areas, and in pools below waterfalls; it is quite possible that this sturgeon was in a spawning area. The other 3 adults were captured during the summer in water between 4 and 5 m deep. These fish had presumably spawned in the upper Apalachicola River in the late spring or early summer and had not yet started their characteristic fall, postspawning migration down river.

Two of the 4 adults tagged and released in the upper river were recaptured by anglers snagging below Jim Woodruff Lock and Dam on 27 August 1981 (Table 2). One sturgeon was at large for 453 da the other 948 da. Both fish were recaptured within 270 m of the tagging/release site. It is estimated that from 25 July 1981 – 6 August 1981 approximately 35-40 sturgeon with an average weight of 33-45 kg were snagged below Jim Woodruff Lock and Dam.

Lower River — Two sturgeon were captured in the lower Apalachicola River (river km 100 and below) in August and October. One juvenile sturgeon (264 mm), was captured in the Jackson River (Intracoastal Water-

TABLE 1. Capture location, method and meristic data for Gulf of Mexico sturgeon captured during 1976-1981 from the Apalachicola River, Florida.

Date	Location (river kilometer)	Temperature (C°)	Weight (kg)	Capture Method	Notes
18 August 1976	Jackson River at Murphy Creek (9.6)	28.0°		Gillnet	Brackish marsh
11 May 1977	Jim Woodruff Dam (166.4)	23.9°		Plankton net	Larval fish
26 October 1977	Apalachicola River at Scipio Creek (0.9)	21.9°		Trawl	10 dorsal scutes 26 lateral scutes 9 ventral scutes snout length 100 mm
24 June 1978	Jim Woodruff Dam (169.6)	28.9°		Gillnet	
5 July 1978	Jim Woodruff Dam (169.6)	30.6°		Gillnet	
13 September 1978	Jim Woodruff Dam (169.6)	28.9°		Gillnet	
14 June 1979	Jim Woodruff Dam (169.6)	26.1°	0.3	Gillnet	
28 April 1980	Jim Woodruff Dam (168.8)	20.6°	27.1	D.C. electroshocker	10 dorsal scutes 26 lateral scutes 10 ventral scutes Flowing male
27 July 1981	Jim Woodruff Dam (168.8)	31.7°	29.4	Angler snagging	
27 July 1981	Jim Woodruff Dam (168.8)	31.7°	27.1	Angler snagging	
27 July 1981	Jim Woodruff Dam (168.8)	31.7°	67.9	Angler snagging	
27 July 1981	Jim Woodruff Dam (168.8)	31.7°	56.6	Angler snagging	

TABLE 2. Tag returns of sturgeon tagged in the Apalachicola River, 1977-1981.

Date Tagged	Location (river kilometer)	Length at Tagging (mm)	Date Recaptured	Recapture Location (river kilometer)	Length at Recapture (mm)
13 September 1978	169.5	1570	28 July 1981	169.6	----
28 April 1980	168.8	1600	28 July 1981	169.6	1651

way) at the mouth of Murphy Creek, a brackish marsh area, on 10 August 1976. It is not known if this area is an important spawning or nursery area.

One subadult sturgeon (505 mm) was captured 26 October 1977, at a water temperature of 21.9°C, during presumed postspawning migration in the lower Apalachicola River (river km 0.6). The dates of capture throughout the different sections of the river corroborate Huff's theory that sturgeon exhibit an upriver, prespawning migration in the spring and postspawning, downriver migration in the fall in southern rivers. The upper Apalachicola River (river km 160 and above) appears to be an important sturgeon spawning area, partly because of the existence of remnant limestone shoal areas. We believe this potential spawning habitat should be protected and preserved.

Commercial fishing for sturgeon has become almost nonexistent in the lower Apalachicola River, indicating a possible declining and unstable population. The population should be closely monitored.

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PREVALENCE OF SELECTIVE PATHOGENS IN NORTH-CENTRAL FLORIDA RECREATIONAL WATERS—*Ricardo J. Alvarez*[1] Food Science and Human Nutrition Department, University of Florida, Gainesville, Florida 32611.

ABSTRACT: *The prevalence of* Serratia marcescens, Pseudomonas aeruginosa, Yersinia enterocolitica, Edwardsciella tarda *and* Chromobacterium violaceum *was studied in 18 recreational waters in the North-Central Florida area. Samples were obtained during the summer 1979 and winter 1980. Temperature and pH were lower during winter and the incidence of the pathogens was higher during the winter. Overall, 44% of the waters samples contained* S. marcescens, *50%* P. aeruginosa, *56%* C. violaceum *and 11%* Y. enterocolitica. E. tarda *was not found.*

THE North-Central Florida area has many bodies of water for recreational use. Few studies have dealt with the overall microbial quality of these lakes and streams. I monitored the presence of selected pathogens (*Serratia marcescens, Pseudomonas aeruginosa, Yersinia enterocolitica, Edwardsciella tarda* and *Chromobacterium violaceum*) in these waters. Although no confirmed waterborne disease outbreaks from these organisms have been reported to-date in Florida, the water quality of our recreational waters must be of concern. The need for closer monitoring of these waters is stressed. These data are part of a larger study involving the microbiological quality of Florida's recreational waters.

MATERIALS AND METHODS—Water samples were collected during the summer of 1979 and winter of 1980 from the top 10 cm of the water columns of each body of water onto sterile sampling bottles. Each body of water was sampled 3 times in duplicate during each season. Tables 1 and 2 list the recreational water sampled. Samples were collected between 1000 and 1600 hrs. Temperature was measured on site, and pH was measured using a Corning model 130 pH meter (Orion Research Inc., Cambridge, MA).

Serratia marcescens: Eleven milliliters of each dilution were inoculated onto Gram Negative Broth (GN, Difco) and incubated at 35 C for 24 hrs. After this incubation period, triplicate Deoxyribo-Nuclease Agar (DNAase, Difco) plates were streaked and incubated at 35 C for 24 hrs. Presumptive colonies (DNAase positive, pigmented or nonpigmented) were transferred to Trypticase Soy Broth (TSB). After 35 C for 7-8 hrs, each TSB tube was restreaked onto DNAase agar again. After 18-24 hrs, red and white colonies with a clear zone were transferred to Triple Sugar Iron (TSI) Agar slants. Typical colonies were further identified biochemically following descriptions in Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

Pseudomonas aeruginosa. Tripilcate Cetrimide agar plates (Brown and Lowbury, 1965) were directly spread plated from each dilution and incubated at 42 C for 48 hrs. Colonies with yellow-green or blue-green fluorescence under a UV lamp were suspected as *Pseudomonas.* Further biochemical tests were performed following descriptions in Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

Yersinia enterocolitica. Eleven milliliters from each dilution were added to Phosphate-Saline buffer, pH 7.4 (Mehlman et al., 1978) and incubated at 4 C. Samples were streaked into Bismuth Sulfite (BS, Difco) every 2 da for up to 21 da. BS was incubated at 25 C for 48 hrs. Typical colonies were inoculated into TSI agar. Organisms with typical reactions on TSI slants were further confirmed by biochemical tests (Buchanan and Gibbons, 1974). Oxidase, catalase and motility at 35 C and 25 C were immediately performed on each presumptive isolated colony.

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Edwardsciella tarda: Pre-enrichment of each sample was done using Lactose Broth (LB, Difco) for 24 hrs at 35 C. Selective enrichment was done using Strontium Chloride B (Iveson, 1973) incubated at 42 C for 24 hrs. Eleven milliliters from each pre-enrichment sample were transferred to Strontium Chloride B broth. Triplicate Xyline Lysine Deoxycholate (XLD, Difco) agar plates were streaked from each Strontium Chloride B tube. Typical colonies were inoculated onto TSI tubes and an indole test was performed from the presumptive TSI slants to screen out non- *Edwardsciella* colonies. Typical colonies were further verified biochemically (Buchanan and Gibbons, 1974).

Chromobacterium violaceum: Triplicate Bennett's agar plates containing neomyacin, cycloheximide and nystatin (Keehle and Cross, 1979) added were streaked with each appropriate dilution. Plates were incubated at 35 C for 48-72 hrs. Typical colonies were verified biochemically using descriptions in Bergey's Manual (Buchanan and Gibbons, 1974). Both pigmented and non-pigmented colonies were selected for verification.

TABLE 1. Incidence of pathogens in selected recreational waters during the Summer of 1979.

	Organisms/ml of Sample				
Recreational Water	*S. marcescens*	*P. aeruginosa*	*Y. enterocolitica*	*E. tarda*	*C. violaceum*
Lake Wauberg-boating	–[a]	104	–	–	30
Lake Wauberg-swimming	–	164	–	–	64
Imperial Lake	54	–	–	–	102
Hogtown Creek (S.W.)	63	–	–	–	–
Hogtown Creek (N.W.)	–	–	–	–	–
Bivens Arm Lake	–	–	–	–	–
Stoneridge Lake	–	96	–	–	–
Unicorn Lake	–	–	–	–	–
Lake Alice	152	–	–	–	–
Lake Little Santa Fe	–	–	–	–	48
Jeff's Creek	–	–	–	–	–
Duck Pond	84	108	–	–	–
16th Creek	–	–	–	–	30
Gainesville Prairie	65	30	–	–	78
YMCA Camp Lake	–	–	–	–	–
Union Pond	–	–	–	–	98
Engineering Creek	43	124	–	–	–
Food Science Pond	–	–	–	–	–
Average	63	104	0	0	65
% isolation[b]	33	33	0	0	39

[a]None detected.
[b]Percent of recreational water containing the pathogen.

RESULTS AND DISCUSSION—To control the spread of waterborne diseases, information on recreational water quality must be available to influence decisions concerning the use of the specific water. This information is obtained by monitoring the water for specific organisms or groups of organisms.

Table 1 and 2 show the prevalence of the selected pathogens in the recreational waters studied. In general, isolation of the pathogens increased during winter. This is probably due to the reduction of the coliform popula-

TABLE 2. Incidence of pathogens in selected recreational waters during the Winter of 1980.

Recreational Water	Organisms/ml of Sample				
	S. marcescens	*P. aeruginosa*	*Y. enterocolitica*	*E. tarda*	*C. violaceum*
Lake Wauberg-boating	–[a]	72	–	–	108
Lake Wauberg-swimming	43	110	–	–	154
Imperial Lake	52	64	–	–	42
Hogtown Creek (S.W.)	32	–	–	–	–
Hogtown Creek (N.W.)	–	–	–	–	–
Bivens Arm Lake	68	–	–	–	92
Stoneridge Lake	71	98	–	–	–
Unicorn Lake	–	–	–	–	–
Lake Alice	–	128	–	–	104
Lake Little Santa Fe	–	–	30	–	–
Jeff's Creek	–	–	–	–	–
Duck Pond	61	–	–	–	–
16th Creek	–	204	30	–	68
Gainesville Prairie	94	–	–	–	–
YMCA Camp Lake	–	–	–	–	48
Union Pond	–	–	–	–	–
Engineering Creek	–	118	–	–	96
Food Science Pond	–	–	–	–	–
Average	52	113	30	0	89
% isolation[b]	39	39	11	0	49

[a] None detected.
[b] Percent of recreational water containing the pathogen.

tion during winter. The average water temperature during the winter months was 14.4 C (11.4-19.1 C), while during the summer the average was 27.1 C (23.4-34.2 C). In addition, during winter the pH of the water ranged from 6.5-7.1, while in the summer the range was much wider, 6.7-8.4.

In 1972, Lassen reported that water may be a significant environmental reservoir for *Y. enterocolitica*. *Y. enterocolitica* was only recovered during the winter. This is not surprising because Bottone (1977) has suggested that the colder environments were more conducive for the growth of this organism. No *E. tarda* was isolated in any of the waters sampled, although it might be expected that *E. tarda* would be present in surface water, especially as a contaminant of reptiles. It has only been reported once in Florida's surface waters (White et al., 1973). Additional work is required to determine the most appropriate enrichment media for the recovery of *E. tarda* from environmental samples. *Serratia marcescens* appears to be widely distributed in the waters of Alabama (Farmer et al., 1973). In contrast, in Florida's recreational waters this organism was isolated 33 to 39% during the summer and winter, respectively. *Pseudomonas aeruginosa* isolated from 33 to 39% of the waters sampled during the summer and winter, respec-

TABLE 3. Incidence of the selected pathogens in the 18 recreational waters sampled during both seasons.

	% isolation
Serratia marcescens	44 (8)[1]
Pseudomonas aeruginosa	50 (9)
Chromobacterium violaceum	56 (10)
Edwardsciella tarda	0 (0)
Yersinia enterocolitica	11 (2)

[1] Number of lakes containing the pathogen.

tively, has been described as a potential waterborne pathogen. Hoadley (1977) states that its isolation from waters including surface recreational waters should be regarded with concern. *Chromobacterium violaceum* was the most predominant organism found in the recreational waters sampled. The presence of this extremely virulent organism in our recreational waters must be of concern. The organism is invasive and produces cyanide (Keehle and Cross, 1977). All of the 7 reported cases of *C. violaceum* infections in the United States have occurred in the Southeast, with 5 in Florida (Rutz, 1974). All 5 persons died.

Table 3 shows the percent isolation of the selected pathogens from the recreational waters sampled in the entire study.

Interestingly, Tables 1 and 2 show that the swimming area of Lake Wauberg contained more organisms than did the boating area. The interaction between these pathogens and potential swimmers of these recreational waters should be further investigated. Ingestion of water while swimming is a possible route of entry for these pathogens.

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TAR BALL POLLUTION IN THE WESTERN CARIBBEAN—*John R. Wyatt*, Zoology Department, University of the West Indies, Mona, Kingston 7, Jamaica.

Abstract: *Frequency and distribution of tar balls in plankton samples from the Western Caribbean are described. Thirty-eight percent of the plankton samples was polluted with the highest frequency of pollution being west of Jamaica in an area of convergent currents.*

Oil pollution in the western Caribbean other than large spills is poorly documented, although it may be a more widespread phenomenon than previously known. While sampling plankton in the Cayman and Caribbean seas around Jamaica I observed that the sampling gear frequently collected small tar balls; the frequency and distribution of these oil polluted samples are documented.

Methods—Sampling was with a 1 x 2 m neuston net with 1.0 mm terylene knotless mesh. All tows were for 15 min and the net sampled the top 750 mm sea surface filtering approximately 3475 cubic meters at each station. The net was towed 30 m astern and to one side of the ship. During sampling some oil was trapped fouling the net, but most was preserved in the plankton sample. Some error was also caused when flotsam and *Sargassum* were collected in the net and discarded before preserving the sample, since tar balls adhering to the *Sargassum* would also be lost. Due to these errors quantitative analysis could not be attempted. The occurrence of pelagic tar in the samples was recorded on a presence or absence basis and is always an underestimate.

Sampling was done between January 1974 and March 1976 in 7 zones (Fig. 1.): A. Jamaica Passage, B. Morant Cays, C. Kingston and Port Royal, D. Portland Bight, E. South Jamaica Shelf, F. Inshore Negril (0-8 km) and G. Offshore Negril (20 km; 40 km). All areas except C were sampled once every 3 mo unless bad weather curtailed sampling. The Kingston and Port Royal sites were usually sampled weekly.

Results—A total of 199 samples was examined from all zones. Overall, 37.7% of the samples contained tar balls ranging in size from 1-6 mm. The distribution of contaminated samples is in Fig. 1. Sample sizes from most areas were too small to indicate seasonal changes, which could only be attempted for Kingston and Port Royal and Inshore Negril (Table 1).

Discussion—The western Caribbean is a focal point for merchant shipping and oil tankers passing through the Windward Passage (Grove, 1978) and any oil spilled in this area could ultimately affect the Florida Cays through prevailing currents (Brucks, 1971; Metcalf and Stalcup, 1974; Duncan et al., 1977). The same current system is also thought to maintain an Antillean component of the invertebrate fauna of the Florida Cays through larval drift (Voss and Voss, 1960; Ingle et al., 1963; Richards and Goulet, 1976) and the presence of tropical fish in the northern Gulf of Mexico has also been attributed to distribution by planktonic life stages (Caldwell, 1959; Hastings and Bortone, 1976).

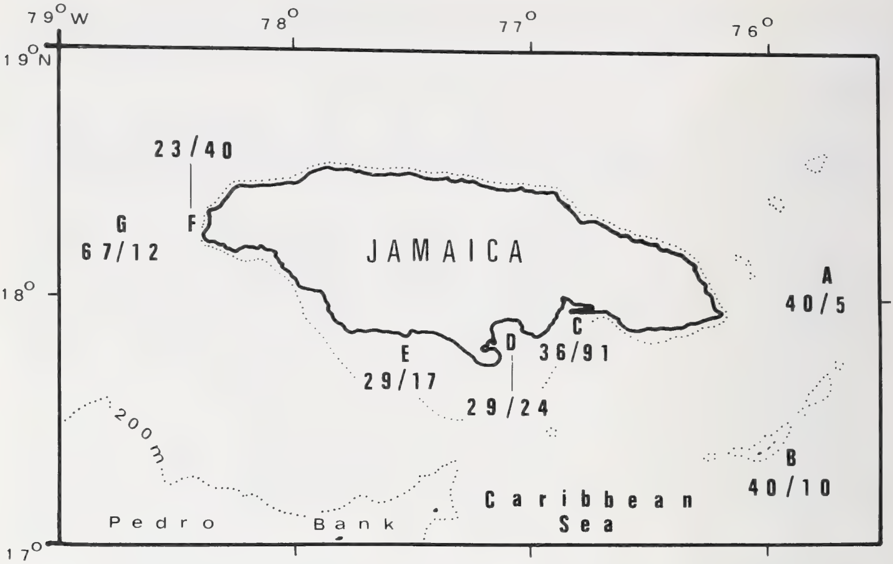

FIG. 1. Distribution of neuston samples and frequency of pollution at stations A to G (see text for place names). Numbers indicate percentage of samples containing tar balls / number of samples.

TABLE 1. Comparison of the frequency of pollution by tar balls in neuston samples during winter and summer at Kingston/Port Royal and Inshore Negril.

Zone	Winter % Polluted	Winter Sample Size	Summer % Polluted	Summer Sample Size
Kingston and Port Royal	33	54	41	37
Inshore Negril	10	21	37	19

Pollution levels in this study were lower than similar samples by Sherman et al. (1974) from the western North Atlantic. Of 39 summer stations in the north Antilles and Bahamas, 87% had tar present; in the winter this area had a 96% frequency of tar. They suggest high pollution levels were concentrated by gyres in the Sargasso Sea. In contrast, there is some indication from my data that tar occurs more frequently in the summer, at least at inshore stations. The highest frequency of pollution in the present study was from offshore Negril (67%). This is possibly due to currents converging from the north and south of Jamaica (Grant and Wyatt, 1980) concentrating particles in this area.

Minor oil patches and tar balls probably originate when ships empty bilges and flush tanks with sea water. Although tar balls would have to be present in high concentrations to affect adult fish they could cause physiological or physical injury if lodged in the respiratory organs or ingested. Tendron (1968), Horn et al. (1970) and Day et al. (1971) all found tar in the guts of fish caught near oil spills. There is, however, little evidence of oil pollution affecting an existing fishery, even in heavily polluted regions (IMCO / FAO, 1977). Nor has oil been proven to affect fish recruitment, although larval mortality from such a cause would be hard to show. Despite this, the deleterious effect of oil on larval fish is well described (Mironov, 1969; Kühnhold, 1970; Sherman and Pearce, 1978). Wells (1972) has shown that crude oil is lethal to lobster larvae.

The possible effects of oil pollution on recruitment cannot be ignored. Oil pollution even at low levels may be damaging to planktonic larvae and small patches of dispersed oil could decrease planktonic recruitment to Florida waters of any organisms which may have a Caribbean origin.

Acknowledgments — This work was supported by the ODA / UWI Fisheries Ecology Research Project of the United Kingdom Ministry of Overseas Development at the University of the West Indies. Thanks are due to Professor I. M. Goodbody and my colleagues in the Project including the crew of the R.V. CARANX.

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Volume 45 Supplement 1

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"U.S. SCIENCE AND TECHNOLOGY BUDGET UNDER STRESS"
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1982

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NOMINATIONS FOR PRESIDENT

The Nominating Committee for President-elect 1982, wishes to announce to all members of the Academy that nominations for this position are now being accepted for consideration. A candidate for this position should

*Have been a member of the Academy in good standing for numerous years.

*Be a widely respected scientist.

*Be willing to devote time to the administrative work of the Academy.

*Be of dynamic personality whose leadership and actions will not merely sustain the Academy, but improve it.

*Be able to identify and analyse special key problems of the Academy and willing to propose and implement remedies.

*Be able to envision new ways and means by which all dimensions of the Academy's activities can improve (in particular membership, organization and financial status).

*Be able to coordinate most efficiently and delegate duties to key members of the Executive Committee.

Nominated candidates will be asked to provide the Committee with a resume and a one-page proposal of their future plans for the Academy if they were to be elected.

Send nominations to:

Dr. P. Papacosta
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FORTY-SIXTH ANNUAL MEETING OF THE FLORIDA ACADEMY OF SCIENCES

at

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22 to 24 April 1982

All registrants for meetings of the Senior and Junior Academy and the Florida Section of the American Association of Physics Teachers are welcome to attend all sessions of all organizations.

John B. Stetson University

The main campus of Stetson University, the oldest private institution of higher learning in Florida, is located in DeLand, 40 miles north of Orlando and 23 miles southwest of Daytona Beach on U.S. Rte. 17-92 (North Woodland Boulevard) 0.5 mile north of its intersection with Florida State Road 44 (New York Avenue). DeLand can be reached by car by taking the following routes: north Florida, U.S. 92 exit of Interstate 95; south Florida, S.R. 44 exit of Interstate 95; southwest and west central Florida, S.R. 44 exit of Interstate 4; Gainesville, U.S. 441 or I-75 to Ocala, S.R. 40 east to U.S. 17; Tallahassee and west Florida, via routes given above for north Florida or Gainesville. The nearest commercial air service is available to Daytona Beach. Participants should use Hulley Field for parking on campus. Refer to the maps on the outside and inside back cover.

Registration

Registration is required for all attendees. A registration desk will be operated in front of Sage Hall from 8:00 am to 3:00 pm on Friday, 23 April, and from 8:00 am to 11:00 am on Saturday, 24 April.

The registration fee is $5.00 for members; members have already received the Florida Scientist Program Issue by mail. The fee for non-members is $7.00 and includes the program. The fee is waived for students, who may purchase the program for $2.00.

Lodging

No reservations can be arranged by the Academy. Please make reservations as soon as possible by contacting the facility of your choice. The first four motels listed below are holding large numbers of rooms for FAS registrants until the indicated deadlines. The others are among the several small motels in DeLand that might have rooms available.

Best Western Executive Inn
S.R. 44 and I-4, DeLand 32720
904-736-3440
5 mi from Stetson University, at intersection of S.R. 44 and I-4.
$21 single; $25 double; $5 each additional person; maximum 2 beds per room; additional cots $5 each; children under age 12 free.
Rates are special and require identification as FAS registrant.
Credit card number or one night's deposit required to guarantee hold for arrival after 4 pm.
Check-in anytime; check-out before noon.
Contact Ms. Susan Dawson by 1 April.

Deltona Inn
481 Deltona Boulevard, Deltona 32725
305-574-6693
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Rates are special and require identification as FAS registrant.
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P.O. Drawer U, DeLand 32720
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Contact Mr. Gene Glor-Vigen or Ms. Jeannie Morgan by 1 April.

Other local motels:

The Boulevard Motel
1349 North Woodland Boulevard, DeLand 32720
$24 single; $28 double; $2 each additional person.

Dixie Motor Lodge
647 South Woodland Boulevard, DeLand 32720
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Food Service

Information about nearby food services will be available at the registration desk. Facilities on campus include a cafeteria and snack bar. A banquet will be held on Friday evening, 23 April, with the 1981 FAS Medalist address by Dr. Humm immediately following. Banquet tickets will cost $8.00 if purchased with preregistration by mail through the Academy office by 1 April; prepaid tickets may be picked up at the registration desk Friday morning, 23 April. A few additional tickets might be available for purchase until noon, 23 April at $10.00.

Stand-Ins and Cancellations

If the author or a coauthor of a scheduled paper cannot present the paper due to illness, unforseen conflict, or other circumstance, the author should arrange for a colleague to read the abstracted paper. If a reader cannot be enlisted, the paper should be cancelled. The Academy should be notified about a reader or an intent to cancel. Early notification will allow inclusion of the change in a program supplement and will spare the author of a cancelled paper the embarrassment of an apparent no-show.

Contact (in preferred order) R.L. Turner, Program Chairman (305-723-3701, ext. 262), Joyce Powers at the Academy office (305-896-7151), the section chair, or the presider of the session.

Field Trips and Tour

Two field trips are scheduled for Saturday afternoon. No charge is involved in either trip. Participants will meet in the Registration Area of Sage Hall at 1:15 pm for instructions, with departure at 1:30 pm.

Washington Oaks State Park (5 mi south of Marineland, Florida). The trip includes a survey of the biotic zonation on the dramatic littoral coquina outcropping of the Anastasia Formation, a walk through a mature coastal hammock bordering the Matanzas River lagoonal estuary, and a walk through the beautiful ornamental gardens and waterways of the Park. The trip will terminate at about 4:30 pm at the Park. About 1 h is required to return to DeLand. The trip will be led by Dr. Keith Hansen of the Stetson University Department of Biology.

Daytona Beach Museum of Arts and Sciences. Among a variety of displays, the recently discovered 17-ft tall giant ground sloth is presented. A guided tour through a nature trail adjacent to the Museum is also available. The visit will terminate at the Museum at about 4:00 pm. The trip will be led by Dr. Derek Barkalow of the Stetson University Department of Biology. At the Museum, participants will be met by Director Garry Libby and Science Curator Mike Brothers.

Gillespie Museum of Minerals. Stetson University houses the finest collection of minerals in the southeast. The Museum, located on the south end of the University campus, will be open on Friday between 1:00 and 5:00 pm for those who wish to view the collection. On Saturday, an organized tour of the Museum will be conducted by Dr. Bruce Bradford of the Stetson University Department of Geography-Geology. This tour will begin at 11:00 am at the Museum, and it will last less than 1 h. The tour must be limited to 30 people; please sign up as early as possible at the FAS Registration Area in front of Sage Hall.

Announcements

Agricultural Science. During preparation of the body of the program, paper AGR-13 was placed out of numerical sequence. The title for this paper is on p. 2.

Atmospheric and Oceanographic Sciences. Where did it go? This section and the Physical Sciences Section have been formally combined as the Physical, Atmospheric, Oceanographic, and Space Sciences Section by request of their members and by approval of the FAS Council.

Council Meeting. There will be a meeting of the FAS Council at 7:30 pm Thursday, 22 April, in Room 204/205 of the Carlton Student Union. All section chairs and chairs-elect as well as other members of the Council should attend.

Einstein Exhibit. The Einstein Centennial Exhibit is on display in Sage Hall, Room 206. It is an illustrated chronicle of the personal life, professional achievements, and philosophy of Albert Einstein. The exhibit was prepared by the American Institute of Physics for the Institute for Advanced Study under a grant from the National Endowment for the Humanities. The exhibit will be open throughout the meeting. Free brochures are available.

Environmental Chemistry. The lead paper for each of the two sessions is a keynote address and will be 30 min long.

Florida Junior Academy of Sciences and Science Talent Search. Members of the Senior Academy are needed as judges for the FJAS paper sessions on Friday and as interviewers for the Talent Search on Saturday. If you would be willing to serve as a judge, please contact Dorothy Henley, Cardinal Gibbons High School, 4520 N.E. 15th Terrace, Ft. Lauderdale 33334 (305-772-4836, after 3:00 pm) or the Academy office (305-896-7151). Information on where judges are needed will also be provided at the Registration Area.

Poster Presentation. A poster will be on display in the hallway near Room 221, Sage Hall from 9:30 am to 4:15 pm on Friday. It is listed as BIO-85. Members are encouraged to submit posters for the 1983 meeting.

Smoking. Stetson University policy prohibits smoking in lecture halls and laboratories.

Special Presentations. In addition to the two plenary lectures, sections have arranged for the following special sessions, keynote addresses, and other special presentations: AGR-13, ANS Sessions A & B, BIO-85, ENV-123 & 128, TCH-176.

Upcoming Symposium. Information will be available at the Registration Area on Tampa BASIS, the Bay Area Scientific Information Symposium scheduled for 3-6 May 1982 at the University of South Florida, Tampa. The symposium will include papers on physical, chemical, geological, meteorological, biological, anthropological, and economic aspects of Tampa Bay and the Bay Area. The organizing committee encourages all participants to register early.

Acknowledgement. The Program Chairman appreciates the help of Duane E. De Freese, who prepared the map on the back cover of this issue.

NOTES

PROGRAM SUMMARY

THURSDAY EVENING, 22 APRIL 1982

7:30 pm	COUNCIL MEETING	C-204/205

FRIDAY MORNING, 23 APRIL 1982

8:00 am	REGISTRATION (to 3:00 pm)	Reg
	Urban and Regional Planning	S-205
8:15 am	Biological Sciences A	S-218
	Biological Sciences B	S-221
	Geology and Hydrology A	S-213
	Physical, Atmospheric, Oceanographic, and Space Sciences A	S-102
9:00 am	Agricultural Science A	C-204/205
9:15 am	Agricultural Science B	C-PDinRm
9:30 am	Biological Sciences C	S-hall
9:45 am	BUSINESS MEETING: Urban and Regional Planning	S-205
10:00 am	Environmental Chemistry	S-102
10:15 am	Anthropological Sciences A	S-205
11:00 am	Agricultural Science C	C-204/205
	Medical Sciences	C-PDinRm
	BUSINESS MEETINGS	
	Biological Sciences	S-221
	Engineering	S-218
	Geology and Hydrology	S-213
11:30 am	BUSINESS MEETINGS	
	Agricultural Science	C-204/205
	Environmental Chemistry	S-102
11:45 am	BUSINESS MEETING: Medical Sciences	C-PDinRm

FRIDAY AFTERNOON, 23 APRIL 1982

1:30 pm	PLENARY SESSION I	E-Aud
2:45 pm	Agricultural Science D	C-PDinRm
	Agricultural Science E	C-204/205
	Anthropological Sciences B	S-205
	Biological Sciences D	S-221
	Engineering	S-218
	Geology and Hydrology	S-213
	Physical, Atmospheric, Oceanographic, and Space Sciences	S-102
3:45 pm	Environmental Chemistry B	S-205
4:45 pm	BUSINESS MEETING: Physical, Atmospheric, Oceanographic, Space	S-102

FRIDAY EVENING, 23 APRIL 1982

6:30 pm	BANQUET and PLENARY SESSION II	C-Stetson

SATURDAY MORNING, 24 APRIL 1982

8:00 am	REGISTRATION (to 11:00 am)	Reg
8:15 am	Science Teaching A	S-205
8:30 am	American Association of Physics Teachers, Florida Section	S-102
8:45 am	BUSINESS MEETING: Science Teaching	S-205
9:00 am	Biological Sciences E	S-218
	Biological Sciences F	S-221
	Florida Committee on Rare and Endangered Plants and Animals	S-213
9:15 am	Anthropological Sciences C	S-205
9:30 am	Social Sciences	C-204/205
10:00 am	Science Teaching B	E-Aud
10:30 am	Anthropological Sciences D	S-205
10:45 am	BUSINESS MEETING: Social Sciences	C-204/205

11:00 am	TOUR: Gillespie Museum of Minerals	Mus
11:15 am	BUSINESS MEETING: American Association of Physics Teachers	S-102
11:30 am	BUSINESS MEETING: Florida Committee on Rare/Endangered P & A	S-213

SATURDAY AFTERNOON, 24 APRIL 1982

1:00 pm	Anthropological Sciences E	S-205
1:15 pm	FIELD TRIPS: State Park & Museum of Arts and Sciences	Reg
2:45 pm	BUSINESS MEETING: Anthropological Sciences	S-205

BUILDING and ROOM ABBREVIATIONS: Carlton Student Union (C)--Room 204/205, Private Dining Room, The Stetson Room; Elizabeth Hall Auditorium (E-Aud); Gillespie Museum of Minerals (Mus); FAS Registration Area (Reg) (in front of Sage Hall); Sage Hall (S)--Rooms 102, 205, 213, 218, 221, hallway near Room 221 (hall).

NOTES

PLENARY SESSION I

of the

FLORIDA ACADEMY OF SCIENCES

DANIEL B. WARD, President, presiding

Friday, 23 April 1982
Elizabeth Hall Auditorium
Stetson University

1:30 pm Welcoming Remarks. Dr. THOMAS TURNER, Provost, Stetson University

1:35 pm Introduction. Dr. HAROLD P. HANSON, Executive Director, The Congressional Office of Science and Technology

1:40 pm U.S. Science and Technology Budget under Stress. The Honorable DON FUQUA, Chairman, The U.S. House Committee on Science and Technology

2:10 pm BUSINESS MEETING: The Florida Academy of Sciences

BANQUET and PLENARY SESSION II

of the

FLORIDA ACADEMY OF SCIENCES

DANIEL B. WARD, President, presiding

Friday, 23 April 1982
Carlton Student Union, The Stetson Room
Stetson University

6:30 pm Punch-Bowl Mixer

6:45 pm Banquet (meat dish of roast beef)

8:00 pm The Future of Seaweed Cultivation in Florida. Dr. HAROLD J. HUMM, 1981 FAS Medalist

8:45 pm Presentation of the 1982 FAS Medalist Award, presented by Dr. THOMAS D. CARR, 1980 FAS Medalist

NOTES

AGRICULTURAL SCIENCE

FRIDAY 9:00 am Carlton Student Union, Room 204/205
SESSION A: No-Tillage and Multicropping
D.D. BALTENSPERGER, University of Florida, presiding

9:00 am AGR-1 Bahiagrass Regrowth After Grain Sorghum. T.V. CUNILIO AND RAYMOND N. GALLAHER, Agronomy, IFAS, UF, Gainesville, 32611. Research is needed on cropping systems to more intensely utilize the two and one-half million acres of improved bahiagrass (Paspalum notatum Flugg) pastures in Florida. This study evaluated bahiagrass regrowth after an old sod was used for multicropping, tillage, and N systems. Four treatments preceeding sod regrowth data were: (1) Spring no-tillage grain sorghum (Sorghum bicolor L. Moench) in sod. (2) Conventional tillage of sod in Spring for grain sorghum. (3) Conventional tillage of sod in the Fall for lupine (Lupinus sp.) followed by no-tillage grain sorghum in the Spring. (4) Conventional tillage of sod in the Fall to plant lupine followed by conventional tillage of lupine in the Spring to plant grain sorghum. Five rates of N were treatments applied to the grain sorghum. Bahiagrass regrowth was best for systems 1 and 3 with average yield of 869 and 826 kg dry matter/ha, respectively. This was confirmed by percent ground cover of weeds and grass. Nitrogen recycling was greatest for system 3 in which lupine preceeded grain sorghum.

9:15 am AGR-2 Affect of Nitrogen Fertilizer on No-Tillage Versus Conventional Tillage Corn in Bermudagrass Sod. A.J. SALDIVAR AND RAYMOND N. GALLAHER, Agronomy, IFAS, UF, Gainesville, 32611. Research has shown that corn (Zea mays L) grown under no-tillage management may require more N to achieve a good level of production as compared to conventional tillage corn. This experiment was conducted to evaluate corn hybrid response to N fertilizer when planted conventional and no-tillage in an old bermudagrass(Cynodon dactylon pers.) sod. Whole plots were tillage, hybrids were split plots and N rates were split-split plots. Total dry matter (DM), N and P concentration in DM, and invetro organic matter digestibility (IVOMD) data were determined. Lack of rainfall and limited irrigation were major factors contributing to low yield. Yields were maximized with only 56 kg/ha N. Bermudagrass regrowth competed for moisture and N in no-tillage corn, reducing dry matter production as compared to conventional tillage corn. Conventional tillage corn had higher yields, IVOMD, and concentrations of N and P in plant material.

9:30 am AGR-3 No-Tillage and Conventional In-Row Chisel Planting of Corn on Flatwood Soils. W.R. OCUMPAUGH AND RAYMOND N. GALLAHER, Agronomy Dept.,IFAS, UF, Gainesville, 32611. Florida, as does much of the world, has flat low sea level soils that are often called "Flatwood Soils". In-row chisel planting techniques have not been examined on these soils, particularily under minimum tillage management. This research was conducted to evaluate corn response from in-row chisel planting on both conventional and no-tillage corn (Zea mays L.) in the Florida Flatwoods. Three experiments were conducted, all on Pomona sand (sandy, siliceous, hyperthermic Ultic Haplaquods). Corn forage yield was greatest from in-row chisel plots in all experiments. This was not true for grain yield,however. Only in the conventional tillage study did in-row chisel give better grain yield. Yield in no-tillage experiments were equal to or greater than for corn in conventional tillage experiments. It was estimated that five and three times more fuel and time, respectively were required to grow corn by conventional tillage than for no-tillage.

9:45 am AGR-4 Effect of digitgrass growth suppression on yield of sod-seeded corn and sorghum. R. KALMBACHER AND P. MISLEVY, Ona ARC, Ona 33865. Corn (*Zea mays*), sugar and grain sorghum (*Sorghum bicolor*) were sod-seeded in digitgrass (*Digitaria penseii*) which was unherbicided (check) or sprayed with glyphosate ((N-phosphonomethyl) glycine) at 3.35 kg/ha (active) or paraquat (1,1'dimethyl-4,4' bipyridium dichloride) at 1.12 kg/ha (active). Sod suppression as indicated by digitgrass dry matter (DM) production after the corn or two sorghum harvests was 7.3 metric tons/ha (mt/ha) in the check, 6.3 mt/ha in the paraquat and 0.0 mt/ha in the glyphosated sod. Glyphosate terminated sod growth 10 days after spraying, but after 14 days little differences were found between paraquat and check treatments. Suppression with glyphosate resulted in greater crop yield (sugar sorghum, 42.0 mt/ha; corn, 24 mt/ha; grain sorghum, 23 mt/ha). Corn yield in the paraquat treatment was 11 mt/ha, sugar sorghum yielded 6 mt/ha, and grain sorghum was 3 mt/ha. The check resulted in 3 mt/ha of corn, but sorghum crop failure. These data indicated greater sod suppression was needed with sod-seeded sorghum than corn.

10:00 am AGR-5 Corn Production Following 2 Clover Species as Affected by Clover Utilization and Tillage Method. R. L. STANLEY, JR. AND DAVID L. WRIGHT, IFAS, Univ. of Fla., AREC, Rt. 3, Box 638, Quincy, FL 32351. Crimson clover (Trifolium incarnatum) and arrowleaf clover (Trifolium vesiculosum) grown under several forage utilization methods were followed by corn (Zea mays) which was managed several different ways including no-till and conventional tillage methods of planting and cultivating. When all clover forage was plowed under and corn planted and cultivated by conventional methods yields were the same behind the two clovers (87 q/ha). All other treatments resulted in higher corn yields following crimson than arrowleaf clover. Highest grain production (104 q/ha) was following crimson clover which had been killed by broadcasting Paraquat with no-till planting and no cultivation. Yield from the same treatment on arrowleaf clover was 90 q/ha. No nitrogen was applied to the corn with P_2O_5 and K_2O each applied at 224 kg/ha.

10:15 am AGR-6 Spacing and Bed Configuration for Grain Sorghum Following Potatoes in Northeast Florida. D.R. HENSEL, RAYMOND N. GALLAHER, and N. MATEO,University of Florida, IFAS, ARC, Hastings, 32084, and Agronomy, Gainesville, 32611. Spring potaotes (Solanum tuberosum L.) in northeast Florida are planted on 1.0 m beds. Growers use a single row spacing for grain sorghum (Sorghum bicolor(L.) Moench) which is an inefficient utilization of space. This study was designed to achieve maximum grain yields by increasing stands and without making major changes in present cultural practices. During 1977 and 1978, spacing variables were placed on 1.0, 1.5, and 2.0 m beds for a total of 16 treatments. Highest yields (3329 kg/ha) were observed with 3 and 4 rows on 2.0 m beds which were 38% higher than the check (1 row on 1.0 m bed). Three rows on 1.5 m bed resulted in 30% increase while 2 rows on 1.0 m bed averaged 20% increase. Similar results also existed for total dry matter yields. Nutrient concentrations and total uptake values did not indicate any differences due to the bedding variables.

FRIDAY 11:00 am Carlton Student Union, Room 204/205
SPECIAL SESSION C: Keynote Address
RAYMOND N. GALLAHER, University of Florida, presiding

11:00 am AGR 13 Opportunities for Application of Intelligent Machines in Agriculture. G.W. ISAACS, Chairman and Professor, Department of Agricultural Engineering, Institute of Food and Agricultural Sciences, University of Florida, Gainesville 32611.

FRIDAY 11:30 am Carlton Student Union, Room 204/205
BUSINESS MEETING: Agricultural Science Section
RAYMOND N. GALLAHER, University of Florida, presiding

FRIDAY 9:15 am Carlton Student Union, Private Dining Room
SESSION B: Multiple Cropping Systems
JERRY M. BENNETT, University of Florida, presiding

9:15 am AGR-7 Potential of Sunflower in Multicropping Systems in the Southeastern United States. VAL J. EYLANDS, Agronomy Dept. IFAS, UF, Gainesville, 32611. Farmer demand is for a short-season crop with a low water requirement for use in various multicropping systems, especially where double cropping soybeans (*Glycine max* L.) carries a high risk. Sunflower (*Helianthus annus*) has been introduced in the past but met with limited success because of marketing and technical assistance problems. Despite adverse growing conditions sunflower double cropped behind irrigated corn (*Zea mays* L) has averaged 1200 kg/ha while using residual fertilizer from the corn crop. Dryland sunflower double cropped behind wheat (*Triticum aestivum* L.) has averaged 950 kg/ha. In both systems sunflower has provided net returns equal to or greater than that of soybeans with a much lower risk factor and a lower level of management. A market outlet offering forward contracts for sunflower has been established in southern Georgia.

9:30 am AGR-8 Nitrogenase Activity Measurements in Summer Green Manure Crops. K.C.S. REDDI* AND G.M. PRINE, Agronomy, IFAS, University of Florida, Gainesville, 32611. Ten summer legumes were evaluated under fumigation and non-fumigation for their nitrogen-fixing capacity by acetylene reduction procedure. There were no significant differences between fumigated and non-fumigated legumes. Nitrogen amounts fixed were joint vetch and soybean, 1.5 and 0.4 kg N/ha/day respectively up to 150th day; *Crotalaria* sp. (PI 436527), 0.4 kg N/ha/day up to 125th day; mungbean and Norman and FL 81d pigeonpeas, 0.35 kg N/ha/day up to 90th day. Hairy indigo and alyceclover started with negligible amounts of fixation and went up to 0.3 kg N/ha/day at 155th day and 1.0 kg N/ha/day at 106th day respectively. Showy crotalaria and velvet bean started with about 0.6 and 0.3 kg N/ha/day respectively at 32 day and then slacked off to negligible amounts. Due to incomplete recovery of nodules, the estimates of velvet bean, pigeonpeas and hairy indigo are below their original activity. Nodule dry weights closely correlated with the activity in all the crops.

9:45 am AGR-9 Effect of Tillage on the Growth Curves of Rye and Soybean in Succession Multicropping. THOMAS J. POST AND RAYMOND N. GALLAHER. Agronomy, IFAS, UF, Gainesville, 32611. This research was undertaken to study the effects of long-term no-tillage/multicropping management on the growth of two agronomic crops. The plots used had previously been under four consecutive years of no-tillage management using a succession of rye (*Secale cereale*) followed by soybean (*Glycine max*), both with and without subsoiling, in a randomized complete block design. Depth of tillage treatments were imposed as split plots over the former experiment. The soil was an Arrendondo fine sand, a member of the loamy siliceous family of the grossarenic Paleudults. In general, tillage of the old no-tillage plots to a depth of 15 cm enhanced growth in both rye and soybean crops. This is probably due to mineralization of accumulated surface residues. Where no-tillage was continued, subsoiling appeared to improve growth, particularly during latter growth stages. This may be due to improved root penetration/water uptake due to subsoiling.

10:00 am AGR-10 Growth Curves and Dry Matter Partitioning in a Corn Forage-Soybean and Corn Grain-Soybean Double Cropping Succession. D. M. FRAISER AND R. N. GALLAHER, Agronomy, IFAS, UF, Gainesville, 32611. Double cropping systems of soybeans (*Glycine max* L. Merrill) succeeding corn (*Zea mays* L.) in the warm season is gaining in practice by farmers in the southeastern United States. This study evaluated growth curves of double cropping systems including corn for grain succeeded by soybeans versus corn for forage succeeded by soybeans. Cultivars in both systems were "DeKalb XL71" corn and "Cobb" soybeans. The study was conducted on an Arredondo loamy sand (member of the loamy silicious hyperthermic family of the grossarenic Paleudults). The corn crops were fertilized with 168, 56, and 135 kg N, P, and K, respectively/ha/yr. Potassium, P, and the first increment of N were applied at planting. No fertilizer was applied to the soybeans. Growth curves of the entire plant and of plant components are presented for each crop, along with an analysis of dry matter partitioning for the crops. The curves differed significantly between the two cropping systems. Soybean dry matter and yield was greater following corn grain as compared to corn forage.

10:15 am AGR-11 Optimizing Grain Yields with Irrigation and Scheduling Nutrient Applications when Doublecropping Corn with Grain Sorghum. DAVID L. WRIGHT AND F. M. RHOADS, University of Florida, Quincy AREC, Route 3, Box 638, Quincy, FL 32351. Intensive management of corn (*Zea mays* L.) followed by grain sorghum (*Sorghum bicolor* L.) has resulted in grain yields of 25207 kg/ha per season. Corn yields under dryland conditions in Florida averages about 2822 kg/ha or 1/10 of what can result with two crops and irrigation. Planting dates and high yielding hybrids of both corn and grain sorghum are a necessity. Certain corn hybrids have produced 6000 kg/ha more grain than other hybrids similar management. Scheduling macro and micronutrient applications on corn has resulted in grain increases of 1500 kg/ha. Large fertilizer applications on corn makes it an ideal crop to doublecrop behind when corn is harvested by July 15 to 25. Grain sorghum yields of 7945 kg/ha after corn need only 112 kg/ha of nitrogen resulting in more fully utilizing residual fertilizer, the land, irrigation system, other machinery, and the long growing season of Florida.

10:30 am AGR-12 Microcomputers as a Viable Alternative to Central Computers: Their Costs and Uses. DAVID BLOCK, Building 631, Agronomy Department, Institute of Food and Agricultural Sciences, Gainesville 32611. The development of small and inexpensive computers during the past few years has made it possible for individual units of large organizations to become self-supporting in most of the functions which up to now have been delegated to computing centers. Easy operation of these computers is possible because comercial programs are available which guide the user in their operation, including word processing systems as well as general problem-solving and statistical analyses. Attractive possibilities of five thousand dollar computers include maintaining personal files of references to the literature and easy typing and editing of manuscripts.

FRIDAY 11:00 am Carlton Student Union, Room 204/205
SPECIAL SESSION C: Keynote Address
RAYMOND N. GALLAHER, University of Florida, presiding
(NOTE: see p. 2 for program)

FRIDAY 11:30 am Carlton Student Union, Room 204/205
BUSINESS MEETING: Agricultural Science Section
RAYMOND N. GALLAHER, University of Florida, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 2:45 pm Carlton Student Union, Private Dining Room
SESSION D: Plant-Soil Analysis and Crop Management
W.R. OCUMPAUGH, University of Florida, presiding

2:45 pm AGR-14 Cyclic Uptake of Potassium by Peanut. RAYMOND N. GALLAHER, Agronomy, IFAS, UF, Gainesville, 32611. One function of K in plants is thought to be its association with movement of photosynthate from the source to the sink. This sutudy dealt with dry matter accumulation and K uptake by peanut (Arachis hypogaea L. "Florunner") as influenced by age and treatment of foliage with a commercial material called "Bayfolin Plus". Dry matter accumulation for leaves, stems, and roots reached a maximum when nuts started forming in pods at about 70 to 90 days after seeding. These plant parts then lost weight until about 110 to 120 days after seeding and started increasing in weight once more. Some parts had weights greater at 140 days than was found at the 70 to 90 day peaks. Dry matter accumulation by leaves, stems, and roots was cyclic, whereas an almost linear accumulation of dry matter occurred in the pods. Potassium uptake followed this cyclic trend indicating that K was positively correlated with dry weight of leaves, stems, and roots and total K uptake fit a fifth order regression equation. Bayfolin Plus treatment delayed maturity in peanut and enhanced K uptake in later stages of growth.

3:00 pm AGR-15 Dieback and Decline of Eucalyptus robusta in South Florida. ROGER S. WEBB AND GEORGE MESKIMEN, University of Florida, 208 Newins-Ziegler Hall, Gainesville 32611, and U.S.D.A. Forest Service, P.O. Box 938, Lehigh Acres 33936. Dieback and decline of Eucalyptus robusta Sm. (robusta breakup) among plantations in Glades County was investigated. Beginning at approximately four years of age, symptomatic trees exhibit a progressive bending or leaning of the main stem accompanied by dieback of the terminal leader, production of adventitious sprouts and frequent stem breakage. Soil and plant tissue analyses of symptomatic and apparently healthy trees revealed a possible association between high tissue levels of Ca and P, and robusta breakup. The effect of micro- and macronutrient imbalances with interference of lignification is discussed.

3:15 pm AGR-16 Plant Elemental Analysis to Determine the Possible Cause and Effect of Dwarfism in Soybean. JANNETT M. FERGUSON, RAYMOND N. GALLAHER, AND KUELL HINSON, Agronomy, IFAS, UF, Gainesville, 32611. Dwarf soybean (Glycine max L. Merrill) plants have been observed in the soybean breeding program at the University of Florida for several years. The dwarf character is controlled genetically and appears to be simply inherited. The cause and effect of this abnormality has not been determined. This study was conducted to evaluate differences in dry matter and elemental concentration in plant parts of dwarf, intermediate, and normal soybean plants in populations segregating for the abnormality. Average plant weight was 45.59, 53.23, 6.66, and 8.37 g for normal , intermediate, dwarf shaded, and dwarf unshaded plants, respectively. Dwarf plants were about one-third as tall as normal and intermediate. Nitrogen and P concentrations were greater in petioles, stems, and tap roots of dwarf plants as compared to normal and intermediate. The sum of the meq/100 g cations K + Ca + Mg was greater in all dwarf plant parts, except podwalls than in normal and intermediate.

3:30 pm AGR-17 Foliar Zinc Nutritionals for Citrus. WILLIAM C. DUCKHARDT AND RAYMOND N. GALLAHER, Agric. Div. , CP Chemicals Inc., Sewaren, N.J. 07077 and Agronomy, IFAS, UF, Gainesville, 32611. Zinc foliar nutritionals differ in their chemical and physicial properties. This study was conducted to evaluate several Zn sources for foliar sprays on citrus. Five Zn sources, $ZnNO_3$, $ZnSO_4$, and Zinc oxides (72 and 60% pure and 50% impure Zn) were applied to the foliage of Valencia two-year old tree seedlings. All Zn materials resulted in greater concentration of Zn in leaves as compared to untreated trees. The $ZnNO_3$ caused a severe leaf burn and eventually over 50% leaf defoliation. The $ZnSO_4$ seedlings had less leaf burn but after three-weeks some leaves had dropped off the young trees. The 72 and 60% Zn materials would be safe and effective products. They coated the leaf well and resulted in good Zn absorption. The 50% Zn product increased leaf Zn significantly over the control but caused leaves to contain 14 times more Pb than leaves from the control trees. Other plant nutrients were measured and will be discussed in relation to Zn treatments.

3:45 pm BREAK

4:00 pm AGR-18 Vegetational Analysis of the Weed Flora of Corn Fields in the Coastal Plain, Fall Zone, and Piedmont of North Carolina. JAMES MCCRIMMON, N.C. State University, Raleigh, NC 27650. The weed flora of selected corn fields in the Coastal Plain, Fall Zone, and Piedmont of North Carolina were classified and described. Twenty-seven corn fields were sampled in August 1976 and August 1977 for a total of 54 fields. Ten .5m x 2m plots were sampled in each field. The vegetational and soil data were analyzed using several ordination (Bray-Curtis, principal components, and reciprocal averaging) techniques and cluster analysis (group average) techniques. Calcium, magnesium, and pH were the only soil variables which significantly correlated with the first axes of the vegetative ordinations. Weed community classes were defined on the basis of the cluster analysis and the reciprocal averaging ordination. There were nine weed classes which were generally located in a particular study area.

4:15 pm AGR-19 Some Plant Tissue Preparation and Storage Problems that Cause Erroneous Analytical Analysis. BRUCE A. FRITZ AND RAYMOND N. GALLAHER, Agronomy, IFAS, UF, Gainesville, 32611. Many scientist require analytical analysis of plant tissue. This research was designed to illustrate many of the plant sample technique preparation problems that can cause erroneous analytical results. Grain sorghum (Sorghum bicolor L. Moench) plants were sampled at mid-flowering stage of growth. One experiment dealt with plant parts and age of leaves. Drying facilities and length of drying time were the variables in the second study. The third dealt with grinding procedures and the fourth study illustrated problems with moisture absorption from improper sample storage. These data illustrate that N concentration is lowest in stems and highest in young leaves. Old leaves tend to have highest mineral concentrations. Improper sampling, mixing, drying, and grinding gave erroneous date. Precise drying at 70 C or higher was necessary to give good N-mineral data. Digestibility data was highest when samples contained some water and when drying was less than 70 C.

4:30 pm AGR-20 Variation and Heterogeneity of Smectites as inferred by Partial Ethylene Glycol Solvations. Y. P. HSIEH AND P. H. HSU, Florida A & M University, P. O. Box 239, Tallahassee, FL 32307 and Rutger University, New Brunswick, NJ 08903. Morphology of the X-ray diffraction patterns of Mg-Smectites, under various unsaturated ethylene glycol solvations, was used as a mean to assess the variation, and heterogeneity of smectites. The results indicated that smectites were different among samples, and heterogeneous within a sample. The heterogeneous layers of smectites were found either randomly mixed in a crystallite, or mechanically mixed in zones or in separated crystallites or combination of the above two cases. The Cameron clay was found randomly mixed with some "illitic" layers, and it was more difficult expandable than other smectites. Characterizing smectites is essential in order to better understand the problems of soil mineralogy, soil physical and chemical properties, and geology of bentonite deposit.

4:45 pm AGR-21 Affect of Nitrogen Fertilizer on Corn and Soybean Yield in Multiple Cropping Succession. W. T. SCUDDER, RAYMOND N. GALLAHER, AND R. B. FORBES, Horticulture, Agronomy, and Soils, respectively, IFAS, UF, Sanford, 32771, Gainesville, 32611, and Sanford, 32771, respectively. Nitrogen is the most limited fertilizer element required by corn (Zea mays L.). When soybeans (Glycine max (L.) Merrill) are inoculated properly with N-fixing bacteria, they seldom respond to addition of inorganic N. This experiment investigated the yield of corn grain succeeded by soybeans as affected by addition of three-rates of N at Gainesville and Sanford, Fl. from 1977 through 1980. Corn was planted in February or early March. Soybeans were planted in early to mid July immediately after corn harvest. Of the 0, 168, and 280 kg N/ha rates added to corn, the 168 kg N/ha rate gave highest corn yields at both locations and for both systems. Soybean yield at Sanford was best following the 168 kg N/ha treated corn systems. At Gainesville,both corn grain and corn forage yield was greatest at the 168 kg N/ha rate but soybean yields were best on 0 kg N/ha treated corn plots after four-years.

5:00 pm AGR-22 **Nitrogen, Phosphorus, and Potassium Fertilization of Two Corn and Soybean Double Cropping Successions. R. B. FORBES, RAYMOND N. GALLAHER, AND W. T. SCUDDER, IFAS, UF, AREC, Sanford, 32771; Agronomy Dept. Gainesville, 32611; and AREC, Sanford, 32771, respectively. The sequential double cropping of corn (Zea mays L.) and soybeans (Glycine max (L.) Merrill) is gaining acceptance in the southeastern USA. This study investigated the N, P, and K fertility requirements of corn harvested for grain and for forage followed by soybeans at Sanford and Gainesville, Fl. Two rates of N (168 and 280 kg/ha), two of P (56 and 112 kg/ha), and two of K (112 and 224 kg/ha) in all eight possible combinations were applied to corn each year. Unfertilized soybeans were planted each year immediately after corn harvest. In general soybean yield was 8 and 12% better behind corn for grain than corn for forage at Sanford and Gainesville, respectivelly. Corn forage systems required more K than corn grain systems. The best combination of N-P-K differed for cropping system and location. The best combination of fertilizer elements for corn did not always give the best yield for the succeeding soybean crop.**

FRIDAY 2:45 pm Carlton Student Union, Room 204/205
SESSION E: Pests in Cropping and Tillage Systems
R.S. KALMBACHER, University of Florida, presiding

2:45 pm AGR-23 Influence of Soil Solarization on Populations of Macrophomina phaseolina and Saprophytic Microorganisms. J. T. ENGLISH, D. J. MITCHELL, & E. L. BARNARD, Dept. Plant Pathology, Univ. of Florida, Gainesville, FL 32611. A comparison of the efficacy of solarization and fumigation in reduction of populations of M. phaseolina (M.p.) and saprophytic microorganisms (potential antagonists of M.p.) in a forest tree nursery soil was made during 1981. Solarization plots were maintained under clear plastic for 33 days. Fumigation plots were treated with Dowfume MC-2 (98% methyl bromide, 2% chloropicrin) under plastic at 977 kg/ha. Control plots were maintained free of any cover throughout the trial. Average pretreatment populations of M.p. were 14.7, 15.3, and 15.2 propagules per gram of soil (ppg) for solarization, fumigation, and no treatment, respectively; average posttreatment populations were 10.2, 0.1, and 14.9 ppg, respectively. Only the fumigation treatment significantly reduced populations of saprophytes. Maximum soil temperatures of 50 and 36 C were attained in solarization plots at 2 and 8-cm depths, respectively; temperatures at equivalent depths of control plots were 43 and 34 C, respectively.

3:00 pm AGR-24 Fluctuations in Populations of Rhizoctonia spp. in a Rye-Soybean, Multi-Cropping System under four Tillage Regimes. R. C. PLOETZ, D. J. MITCHELL, and R. N. GALLAHER, Univ. of Florida, Gainesville, FL 32611. Population densities of soilborne Rhizoctonia spp. (RS) were monitered during 1981 in a split-plot design experiment. Main plots were subsoiled or not subsoiled and subplots were tilled to 15cm (15T) or not tilled (NT). Tillage treatments were replicated four times and were imposed annually beginning in 1976. Generally, mean populations of RS (MD) detected in NT soils were higher than those detected in 15T soils, regardless of subsoiling. MD ranged from 1.2 to 3.6 propagules per gram of soil (ppg) for NT soils and 0.7 to 2.9 ppg for 15T soils in three assays during the rye season (Nov. 25,1980 to May, 1981). Increasing MD for all tillage treatments in the spring coincided with growth of the rye and with increasing minimum daily temperatures. After harvest of the rye and planting of the soybeans (May 23), MD decreased. MD during the soybean season ranged from 0.4 to 1.0 ppg and 0.3 to 1.9 ppg for NT and 15T soils, respectively; midseason low populations were preceded by high daily temperatures.

3:15 pm AGR-25 Influence of a Minimum Tillage-Multicropping System on Populations of Pythium spp.. P. A. RAYSIDE, D. J. MITCHELL, AND R. N. GALLAHER, Dept. of Plant Pathology and Dept. of Agronomy, respectively, Univ. of Florida, Gainesville, FL 32611. After 4 yr. of a soybean (Glycine max "Bragg")-oats (Avena sativa "Florida 501") rotation under conventional and minimum tillage, populations of total Pythium spp. over 1 season of oats and 2 seasons of soybeans ranged from 71 to 163 propagules per gram of soil (ppg). Generally, there were no significant differences found in total populations between tillage practices. Pythium irregulare was the predominant species found, with populations ranging from 13 to 107 ppg of soil. Populations of P. irregulare were highest during the first months of each soybean and oat season and dropped at the end of each season. Populations of P. myriotylum declined from 7 ppg of soil at the beginning of the soybean season to ca. 1 ppg during the oat rotation. Populations of P. irregulare and P. myriotylum associated with soybean and oat root tissue were higher in the first 3 wk. after planting than later in the season.

3:30 pm AGR-26 Minimum Tillage Effects on the Incidence of Beneficial Mycorrhizal Fungi on Agronomic Crops. N. C. SCHENCK, G. S. SMITH, D. J. MITCHELL, and R. N. GALLAHER, Plant Pathology and Agronomy Departments, University of Florida, Gainesville 32611. For two years the incidence of mycorrhizal fungi in soil and roots of several agronomic crops receiving different tillage practices were monitored. Spores of mycorrhizal fungi were wet-sieved from soil samples and roots were cleared and stained to determine intra-root colonization by these fungi. In most cases, minimum tillage practices increased the incidence of mycorrhizal fungi (309 spores/kg soil; 24% root colonization) above that in crops receiving conventional tillage (249 spores/kg soil; 10% root colonization). A greater diversity of species of mycorrhizal fungi, usually more of the plant growth promoting types, occurred with minimum tillage than with conventional tillage. There were generally more spores associated with sorghum (Sorghum bicolor) and soybean (Glycine max) than corn (Zea mays) and more spores associated with oats (Avena sativa) than vetch (Vicia villosa). Subsoiling had little effect on the incidence of mycorrhizal fungi.

3:45 pm BREAK

4:00 pm AGR-27 Competition Between Soybean and Weeds as Affected by Metribuzin Rate and Tillage. SUZANNE DYAL AND RAYMOND N. GALLAHER, Agronomy, IFAS, UF, Gainesville , 32611. Sicklepod (Cassia obtusifolia L.) may be the number one broadleaf pest to soybean (Glycine max L. Merrill) in the southern United States. This experiment determined the degree of sicklepod competition with soybean as affected by rate of metribuzin (Lexone) (4-amino-6-tert-butyl-3-(methyl-thio)-as-triazine-5(4H)-one) and type of tillage. Weed competition decreased as the rate of herbicide increased. Soybean was injured when more than 0.56 kg active ingrediant (ai)/ha was used. When the previous rye (Secale cereale (L.)) crop residue was incorporated prior to planting soybeans, less weed competition occurred as compared to removal of rye residue prior to incorporation. The incorporated residue reduced weeds more at 0 and 0.28 kg ai/ha than at higher rates. Growth curves were fitted to a cubic equation, $y=a+bx+bx^2+bx^3$. The R^2 values showed 98 and 99% explanation for soybean and 87 to 97% for weeds. Similar relationships were found for cumulative energy curves. Weeds competed with soybean for about one-third of the total energy produced.

4:15 pm AGR-28 Economics and Energetics of Weed Control in Soybean Tillage Systems. J.M. GOETTE, W.L. CURREY, AND D.H. TEEM, Department of Agronomy, University of Florida, Gainesville, Florida 32611. Economic and energetic efficiencies of various weed control programs were determined and compared in three soybean[Glycine max (L.)] tillage systems. Weed control programs consisted of various combinations of preemergence and postemergence herbicides. Tillage operations were intensive, minimum, and no tillage. Economic efficiencies were determined by establishing a Cost Efficiency Ratio (CER=dollar return/production cost) for each weed control program. The energy efficiency was determined by comparisons of Energy Productivity (EP=yield weight/total energy input). The four highest efficiency ratings were generated by herbicide treatments containing metribuzin in the minimum tillage system. Weed control programs in the no tillage system generally produced efficiency values double that of the intensive tillage system, both economically and energetically.

4:30 pm AGR-29 Nematode Populations in A Rye/Soybean No-Tillage System After Four Years. D. W. DICKSON, THOMAS J. POST, T. E. HEWLETT, AND RAYMOND N. GALLAHER, Nematology and Agronomy, IFAS, UF, Gainesville, 32611. Nematodes are a major economic threat to soybean (Glycine max L. Merrill) production in Florida. This study evaluated nematodes in a rye (Secale cereale "Werns Sbruzzi") -soybean ("Bragg") double cropping succession as affected by tillage. The soil was an Arrendondo loamy sand (member of the loamy silicious hyperthermic family of the grossarenic Paleudults) and the plots had previously been under four consecutive years of no-tillage management using a rye-soybean succession. Nematode populations in plots which were tilled to a depth of 15 cm were compared to those in plots which were left untilled for the fifth year. Populations of root-knot (meloidogyne sp.), dagger (Xiphinema), ring (Criconemoides sp.), and lesion (Pratylenchus sp.) nematodes were from 0-50 per 250 cm^3 of soil. Numbers were unaffected by tillage in this study. These findings contridict results obtained in other small grain-soybean double cropping successions.

4:45 pm AGR-30 Effect of Crop Rotation, Minimum Tillage and Subsoiling on Nematodes. T.E. HEWLETT, D.W. DICKSON AND R.N. GALLAHER, Department of Entomology & Nematology, and Department of Agronomy, University of Florida, Gainesville, FL 32611. Populations of Criconemoides, Meloidogyne, Pratylenchus, Trichodorus and Xiphinema were monitored in a multi-cropping, minimum tillage, subsoiling study. Meloidogyne decreased in those rotations using sorghum, millet and watermelon and in minimum tillage plots. Pratylenchus increased in rotations using corn forage and corn grain. Crop rotations and tillage methods had little effect on populations of Criconemoides, Trichodorus and Xiphinema. Subsoiling appeared to have little effect on any of the nematode populations.

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

AMERICAN ASSOCIATION OF PHYSICS TEACHERS, FLORIDA SECTION

SATURDAY 8:30 am Sage Hall, Room 102
FRANK A. ANDERSON, The Bolles School, presiding

8:30 am APT-31 Measurement of Very Low Concentrations of Al-26 in Deep Sea Core Samples. R. A. Llewellyn, R. L. Cook, and M. J. Llewellyn, University of Central Florida. Several investigators have proposed using the ratio of the intensities of Al-26 and Be-10, two isotopes produced by spallation, for dating ocean sediments. However, the steady-state production of Al-26 by spallation has been questioned and possible influx of Al-26 with cosmic ray and solar flare activated interstellar dust has been hypothesized. This study reports the preliminary results of analyzing twenty-five deep sea core samples for Al-26 with the aim of determining whether extraterrestrial sources must be postulated.

8:45 am APT-32 Microcomputer Voice Synthesizers. ROBERT G. CARSON, Rollins College. The recent availability of reasonably priced voice synthesizers designed for use on popular brands of microcomputers has increased the possibilities of creating programs which respond orally to the user's input. A brief discussion of several voice synthesis techniques along with their respective advantages and disadvantages will be presented. Particular attention will be focused on several synthesizers; these will be demonstrated using an Apple II microcomputer system.

9:00 am APT-33 Experimental Fusion Research: Intersecting Xe^{+I} Beams. MELISSA CRAY*, Rollins College. A test apparatus and associated experimental techniques have been developed to measure the Xe^{+1} - Xe^{+1} ionization and charge exchange cross sections. Two independent, highly focused Xe^{+1} beams are produced, accelerated, and directed on an intersecting course. Upon beam interaction, ion-ion collisions produce neutral and doubly charged components. Faraday cup collection techniques are then used to read post-interaction currents. This experiment should provide more information about heavy ion beam energy loss and deterioration time for the Ion Beam Fusion project at Argonne National Laboratory. (*Participant in Fall 1981 Student Research Participation Program at ANL.)

9:15 am APT-34 Units as a Problem Solving Tool in Introductory Physics. E. RONALD KIRKLAND, University of Central Florida. The subjects for this study consisted of three classes of physics high school students from Hamilton High School East, Trenton, New Jersey. One class was chosen for control. Two served as the treatment group. Both control and treatment reviewed kinematics and dynamics concepts of physics with text designed by the researcher. The instruction of the treatment group differed from the control in that dimensional analysis was taught and stressed throughout the treatment period. The day before the treatment began a pretest was given. The day following the treatment was devoted to posttest. The pretest was identical to the posttest. The subjects taught dimensional analysis showed significantly ($p<0.01$) higher GAIN scores than the subjects in the control group. The implications of the study will be discussed in regards to physic curricula.

9:30 am APT-35 More Pre-College Physics Essential to American Ascendency. JAMES G. POTTER, Florida Institute of Technology. The only way we can keep up with the Russians is to require more concrete thinking of physical concepts, processes, and relationships by our young people for several years before college. People do not progress to formal and abstract reasoning unless they have first learned to reason in concrete specifics. Until more of this is done before college, colleges must begin physics with less abstraction and generality so that a larger portion of students will undertake to think physics instead of programming themselves to follow routines with little-understood material stored in their memories. Today's top priority concern for the Physics community is to force more Physics with capable teachers into pre-college curricula.

9:45 am BREAK

10:00 am APT-36 Four-fermion Interaction in the Mean-field Expansion. Formation of Cooper Pairs in Four Dimensions. PIOTR REMBIESA, University of Central Florida. The mean-field expansion of a four-fermion scalar-scalar interaction is reconsidered in a two and four-dimensional space-time. We study the model with positive and negative signs of the coupling constant. If the coupling constant is negative, the generating functionals allow the Laplace expansion after reparametrization with the use of the collective boson variables in the fermion-fermion sector. In two dimensions the theory is consistent for positive, coupling constant, in four dimensions for negative coupling constant. Even in four dimensions the theory is renormalized by power counting.

10:15 am APT-37 Symmetry Breaking Solutions of the Dyson-Schwinger Equation. PIOTR REMBIESA, University of Central Florida. The truncated version of the Dyson-Schwinger Equations for the vector and axial-vector electrodynamics is examined for values of the gauge parameter. We show that the unsubtracted version of these equations do not possess physically meaningful solutions neither in the symmetry breaking nor in the symmetry conserving sectors. The subtracted version of these equations was believed to violate the requirements of renormalizability and gauge invariance. We show that the arguments of inconsistency were based on the illegitimate expansion in powers of the coupling constants while the solutions are nonanalytic for $g=0$. The exact solutions to the symmetry conserving case are found. We show they do not satisfy the necessary boundary conditions, in contradistinction to the symmetry breaking case. The results may explain the mechanism of the dynamical $\gamma 5$ symmetry breaking.

10:30 am APT-38 Preparing Students for the 21st Century. Information on the Japanese and Soviets school curricula will be presented. J.J. BRENNAN, University of Central Florida. Since the National Science Foundation has ceased funding efforts in science education, the science community will have to concern itself with course requirements and content in the school in order to prepare students for the opportunities of the future. Job dislocations are occuring as cheaper computers and reprogrammable robots become available. Better preparation in mathematics and the sciences, and introduction of computer language, like LOGO in the lower elementary school, can lead to upward mobility of the individual and the improvement of the nations posture in the world arena.

10:45 am APT-39 Additional Measurements of the Thermal Expansion of Optical Materials. JAMES STEVE BROWDER, MICHAEL BLUME, and ROBERT HUNLEY, Jacksonville University; and STANLEY S. BALLARD, University of Florida. The program previously described[1] continues. The coefficient of linear thermal expansion of the infrared-transmitting materials AgBr and BaF_2 has been measured over the temperature range 77K (liquid nitrogen) to 300K (room temperature). These experiments are now conducted in the Physics Department of Jacksonville University.

[1] Florida Scientist, Vol. 38, Supplement 1, 1975, p. 28.

11:00 am APT-40 Computer Modeling Phenomena for Labs on a TI58 Pocket Calculator. JEFFREY A. MEYERS, Physics Department, University of Central Florida. Several programs which simulate physical problems will be presented in the fields of E & M, special relativity and other non-mechanics areas. They are suitable for inclusion as laboratory exercises for high school or college level laboratories.

SATURDAY 11:15 am Sage Hall, Room 102
BUSINESS MEETING: American Association of Physics Teachers, Florida Section
FRANK A. ANDERSON, The Bolles School, presiding

ANTHROPOLOGICAL SCIENCES

FRIDAY 10:15 am Sage Hall, Room 205
SPECIAL SESSION A: Physical Anthropology of Prehistoric South Florida Indians
M. YASAR ISCAN, Florida Atlantic University, presiding

10:15 am ANS-41 Analysis of Human Skeletal Remains from Pasco County. JOSE GOMEZ AND M. YAŞAR IŞCAN, Florida Atlantic University, Boca Raton, Florida 33431. The purpose of this study is to present an analysis of a skeletal population found in Pasco County in 1980. The burials were excavated as a salvage operation. Approximately 82 individuals were discovered (3 infants, 3 sub-adults, 73 adults, 3 unidentifiable) of which 53 are males (?) and 16 females (?). All of the skeletons were fragmentary and each of the skeletons were represented by a few bones. Age determination cannot be made for the adult members of the population because of the preservation condition. The analysis of these bones indicated the presence of several paleopathological and pseudopathological conditions. Three of these skeletons exhibited possible multiple myeloma, osteomyelitis and 12 cases involving animal bites.

10:30 am ANS-42 Prehistoric Paget's Disease from Florida. M. YAŞAR IŞCAN AND JOSE GOMEZ. Florida Atlantic University, Boca Raton, Florida 33431. Excavation of a prehistoric Indian site representing late Weeden Island and Safety Harbor periods, from Pasco County yielded approximately 82 individuals. The skeletons found at the Briarwoods salvage site were all fragmentary and only a few cranial remains was available to study. However, of the 73 adult skeletons at least one individual showed diagnostic features of Paget's disease (Osteitis Deformans) involving the skull and tibia and femur. While the histological examination supports this diagnosis, the radiographical analysis does not show the clearcut morphology of the disease. Another six specimens also show similar lesions, however, these cannot be radiographically supported. If the diagnosis made in this specimen is correct the presence of Paget's disease is first time seen in Florida.

10:45 am ANS-43 Analysis of a Late Archaic Prehistoric Cemetery. M. YAŞAR IŞCAN AND ROBERT CARR, Florida Atlantic University, Boca Raton, Florida 33431. In April 1981, the Santa Maria site (8Da2132) was discovered as a burial site representing a Late Archaic period. The burials were associated with a few prehistoric artifacts including a bone bead, heavily eroded strombus celt or scraper, a small shark tooth, an oval lump of dried clay and a flat oolitic limestone rock. The site yielded four skeletons which were buried under numerous limestones. The skeletons were sexed to be two females and two males. One of the female skeletons showed a severe osteomyelitic lesion affecting practically all of the long bones. The skull was also infected. A male seemed to have suffered from a violent trauma as detected from the parietal bones. Dental condition indicated that periodontal disease, abscesses, and heavy dental attrition were prevalent during this prehistoric period. Further analysis of the skeletons indicated that the population of this site showed a morphological similarily to those found in the central region of Florida.

11:00 am ANS-44 Cranial Abnormality in Archaic Florida Indian Crania. M. YAŞAR IŞCAN, GARY J. GOSS AND ROBERT CARR, Florida Atlantic University, Boca Raton, Florida 33431. Distinction between man-made, pathological and animal-like changes on human crania has been a challenge for physical anthropologists of prehistoric populations and forensic remains. This study is an attempt to illustrate three crania fround at Santa Maria Site, Miami, which show various structures resulting from factors including man, insects and pathology. The specimens showed a round depression, a complete canal, and three parallel incomplete tunnels. The initial assumption was that they were made by man. However, a review of entomological literature indicates that a beetle species (Dermestidae, Staphylinidae or Scarabaeidae?) might have caused these structural alterations. This paper is an attempt to point out those insects which make such changes on the human skeleton and to make a differential identification of these insect-made structures from those archaeologically physical anthropologically significant ones.

11:15 am BREAK

11:30 am ANS-45 Dental Morphology of a Southeast Florida Indian Population. ROBERT M. BRILLIANT AND M. YAŞAR IŞCAN, Florida Atlantic University, Boca Raton, Florida 33431. The dentition of 50 adults of a Southeast Florida Indian population, circa 1000 A.D., salvaged from site 8PB11, at a condominium project near the ocean in Highland Beach, were analyzed for sexual dimorphism. Each tooth of each sample individual was measured for mesio-distal, bucco-lingual, and crown height dimensions and for the combined lengths of the first two and all three molars for each jaw. The trend observed was that the means of all fifty-two dimensions were nearly equal or slightly larger in the male. Furthermore, a statistically significant difference between the sexes was observed in only a few of the molar dimensions. It is concluded that there is only slight sexual dimorphism in this group's dentition. The metrical findings were analyzed for bio-cultural implications and comparisons were drawn with other Indian populations and with populations from similar environments.

11:45 am ANS-46 The Dental Health of Prehistoric Southeast Florida Indians. JED SCHOEN, ROBERT ISLER AND M. YAŞAR IŞCAN. Florida Atlantic University, Boca Raton, Florida 33431. The dental dealth of prehistoric Florida indians has not been explored in depth. This study is an attempt in that direction. Fourteen dental variables were analyzed for every individual in a skeletal population found in Highland Beach, Florida (8PB11). Among the variables considered were caries, periodontal disease, attrition and hypoplasia. It was observed that dental chipping was common; ante-mortem dental loss and hypoplasia infrequent; dental caries very infrequent; hypercementosis moderate to heavy. There was relatively little crowding and the occlusion was edge to edge. Other than peridontal disease the dental health was fairly good. This study furthermore compares these findings with those of other southeastern United States Indians.

12:00 n ANS-47 Periodontal Disease and Related Pathologies of Prehistoric Southeast Florida Indians. JED SCHOEN, ROBERT ISLER AND M. YAŞAR IŞCAN, Florida Atlantic University, Boca Raton, Florida, 33431. Peridontal disease and its many causitive factors is a challenge to dentists and anthropologists. This study deals with fourteen health related variables and their relationship to dental resorption in a group of circa tenth century AD Florida indians obtained from a burial mound in Palm Beach County (8PB11). Of these variables there is a significant corellation between dental resorption, occlusion, attrition and dental abscess formation. However our data suggests that crowding and dental caries do not seem to be associated with periodontal disease in this population. We conclude that their periodontal problems are related to severe attrition which may have resulted from the abrasive nature of their diet.

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 2:45 pm Sage Hall, Room 205
SPECIAL SESSION B: Roundtable Discussion on Current Trends in Physical Anthropology
M. YASAR ISCAN, Florida Atlantic University, presiding

2:45 pm ANS-48 Physical Anthropology: Old Techniques and the New Application. M. YASAR ISCAN, Department of Anthropology, Florida Atlantic University, Boca Raton 33431.

3:00 pm ANS-49 Physical Anthropology of the Living. LESLIE SUE LIEBERMAN, Department of Anthropology, University of Florida, Gainesville 32611.

3:15 pm ANS-50 Current Trends in Primate Behavior. BARBARA E. ROTHSTEIN, Southeastern College of Osteopathic Medicine, 1750 NE 168 St., North Miami Beach 33162.

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

SATURDAY 9:15 am Sage Hall, Room 205
SESSION C: Biomedical Anthropology
LESLIE SUE LIEBERMAN, University of Florida, presiding

9:15 am ANS-51 Sex Differences on the Sacroiliac Joint Surfaces. KAREN DERRICK and M. YAŞAR IŞCAN, Florida Atlantic University, Boca Raton, FL. 33431. The purpose of this study is to determine the sex from the auricular surfaces of the sacroiliac joint. The test sample includes nine males and six females with an age range of fifteen to sixty-nine years. Based on this sample, although small, the following were found among the most consistent differences on the innominate bone between the sexes: elevation of the surface and sharp demarcation of the posterior border of the horizontal ramus in females, and larger surface and greater width of both rami in males. This study, although based on contemporary black and white population, could be utilized for those skeletons found under archeological conditions in which more reliable structures are lacking or inconclusive.

9:30 am ANS-52 A Nutritional Analysis of the Evolution of the Maya Diet. CHERRY HAMMAN, Department of Anthropology, Florida Atlantic University, Boca Raton, Florida, 33431. It is possible to evaluate the nutritional evolution of the Yucatec Maya diet by utilizing surviving recipes. Hearthrites and food preparation techniques react very slowly to change throughout the centuries. With the aid of 16th century Spanish documentary sources and contemporary oral traditions, research in isolated villages can yield information regarding the prehistoric diet. Ancient recipes may often be distinguished from contemporary ones by language. Pre-Columbian recipes tend to be known by a Maya name; the newer Spanish additions are identified in Spanish. The food value of each recipe can be evaluated by calculating the nutritional content of each ingredient and noting the combination of these ingredients. Certain foodstuffs served in combination have more value than when served separately.

9:45 am ANS-53 The Impact of Haitian Entrants on State Health Services. LESLIE SUE LIEBERMAN, University of Florida, Department of Anthropology, Gainesville, 32611. Approximately 50,000 Haitian Entrants have arrived in the Miami area during 1979-1981. Because of their uncertain immigration status, many women are electing to have U.S. born babies. In the summer of 1981 nearly 20% of all births at Jackson Memorial Hospital, the only public hospital in Miami serving indigents, were to Haitian women. Many Haitian women and children are participants with federally funded Maternal and Infant Care Projects (MIC) and the Special Supplemental Food Program for Women, Infants and Children (WIC). Haitians account for the highest proportion of newly diagnosed cases of tuberculosis. Other health problems included malnutrition, venereal disease, sickle cell anemia, and intestinal parasitization. In addition, crowded and unsanitary housing is creating a number of environmental health problems including large increases in the rat population and new breeding areas for mosquitoes. These health issues and their policy implications are examined in this paper. This research supported by the Dept. of Health and Rehabilitative Services.

10:00 am ANS-54 Ethnocide and Genocide through Biological Warfare: Facts and Allegations. CANDACE G. BRISENDINE, Florida Atlantic University, Boca Raton, Florida 33432. That large numbers of native populations were decimated as a result of the introduction of disease by colonizing Europeans of the 15th, 16th and 17th centuries is well known. Disease unwittingly became an effective weapon of warfare by eliminating large numbers of people or rendering large segments of the population unable to defend themselves. This study deals with the historical use of biological, or germ, warfare in human populations through a survey of earlier literature and discusses recent allegations which suggest that germ warfare has now been included in the arsenal of today's well-armed industrialized nation. As a result, medical anthropologists of urban populations should concern themselves with governmental activities relating to germ warfare and should be aware of the potential misuse of their data when dealing with the environment and ecology of both traditional and industrialized societies.

SATURDAY 10:30 am Sage Hall, Room 205
SESSION D: General Anthropology
J. JEROME SMITH, University of South Florida, presiding

10:30 am ANS-55 Nonverbal Communication from Doctors to Patients. BARBARA E. ROTHSTEIN, Southeastern College of Osteopathic Medicine, 1750 N.E. 168 St. North Miami Beach, FL 33162. The importance of nonverbal communication has been recognized recently in the field of medicine. Some medical schools have even tried to teach future physicians to gain knowledge of the patient's emotional and physical status from postural communication, but it is not known if physicians always convey the intended message to their patients by nonverbal methods. This study will try to (1), identify generally understood and preferred doctor to patient nonverbal rituals by data gained from questionaires and (2), eventually teach medical students to better utilize these rituals to communicate the intended impressions to the patient. This will be accomplished by video taping, playback and discussion in groups of physicians in training.

10:45 am ANS-56 It Don't Mean a Dang if It Ain't Got that Twang: An Ethnography of Rock and Roll. ROBERT J. AUSTIN, Dept. of Anthropology, Univ. of South Florida, Tampa 33620. Ethnographic interviews were conducted with a single informant over a a period of six weeks in an attempt to explore the relationship between sound and meaning as reflected in the language of musicians. Analysis focused on the various terms for musical instruments, their cognitive meanings, and how these influence musician's behavior in terms of creating a "sound" which is both musically creative and emotionally expressive.

11:00 am ANS-57 Plaza Use: Gainesville, Florida's Downtown Community Plaza. DAVID P. REDDY, Department of Anthropology, University of Florida. Plaza use and usefulness are measured according to criteria developed by W. H. Whyte in his book, The Social Life of Small Urban Spaces (1980). Usefulness and applicability of Whyte's methods are discussed and findings on current use levels of the plaza (low), and problems interfering with use are made. Inexpensive ways in which use can be enhanced are suggested.

11:15 am ANS-58 Prompted Code-Switching in Carriacou Creole. RONALD KEPHART, Department of Anthropology, University of Florida, Gainesville 32611. The native language of people of Carriacou, Grenada, West Indies is a local variety of Lesser Antillean Creole English. English is the official language, and the language of the school. Carriacou children, age 13-15 years, were recorded in free conversation as part of a study of Creole English. Since the setting was a school, they were asked to use non-school language. A young man begins a story about crab hunting in school English and the others guide him back into Creole. This sequence is analyzed and the implications of the children's knowledge of their Creole grammar for education in the West Indies are discussed.

11:30 am ANS-59 The Urban Ecology of Ponce, Puerto Rico. ELIZABETH W. HIGGS, Dept. of Anthropology, University of Florida, Gainesville, FL 32611. This study shows how the anthropologist can use secondary data from housing and population censuses to set the stage for primary fieldwork. Four types of multivariate analysis were applied to data available from 1970 on Ponce, Puerto Rico--factor analysis, regression analysis, cluster analysis and trend surface analysis. A low education, below poverty, and high worker dependency factor was found to be a strong factor at work in the distribution of the population in Ponce. The trend surface analysis produced two very useful maps showing the distribution of female factory workers and of large young households. While none of these types of analysis are new, their utility in pointing out appropriate neighborhoods for further anthropological investigation is new. The paper also points out the importance of these types of analyses for describing the larger urban ecological context for neighborhood- or work site- based studies.

SATURDAY 1:00 pm Sage Hall, Room 205
SESSION E: Archaeology of Florida
WILLIAM E. MCGOUN, University of Florida, presiding

1:00 pm ANS-60 Establishment and Development of the Museum of Archaeology. GYPSY C. GRAVES, 1115 N. Rio Vista Blvd., Ft. Lauderdale, Florida 33301. The Museum of Archaeology was established in 1980 in order to convey the archaeological and physical anthropological development in Southeast Florida. Since it was the first museum in anthropology in Broward County, several problems have been encountered in securing assistance from the authorizies and civilians. The purpose of this paper is to illustrate how the founders of the institution have challenged these difficulties and developed necessary methods to meet the educational needs of the general public.

1:15 pm ANS-61 Ficus Tree Site, a Small Salvage Site in Broward County. GYPSY C. GRAVES, 1115 N. Rio Vista Blvd., Ft. Lauderdale, Florida 33301. The Ficus Tree Site was excavated in 1980 by the Broward County Archaeological Society, Inc. Development of the community of Weston by the Arvida Corporation necessitated the destruction of this small site. Analysis of the excavated material revealed one human burial, numerous animal bones and shell, and Glades III cultural material. This paper discusses the archaeological significance of these artifacts with the context of Southeast Florida and entire Florida prehistoric culture.

1:30 pm ANS-62 Use-Wear Analysis of Shell Tools: Archaeological Implications. DANA STE.CLAIRE, University of South Florida, Department of Anthropology, Tampa, FL 33620. Shell tools and shell debitage from the Maximo Point site (8-Pi-19) and other archaeological sites were microscopically observed for recognizable wear patterns resulting from the continued use of these implements. Experimental data was used in conjunction with the use-wear analysis to classify the shell tools on the basis of function rather than morphology. The behavioral implications of a techno-functional approach to the study of aboriginal shell tools in Florida will be discussed.

1:45 pm BREAK

2:00 pm ANS-63 Cultural Continuity in Southeastern Hillsborough County. JAMES M. WELCH, Dept. of Anthropology, Univ. of South Florida, Tampa 33620. Excavations were conducted at a prehistoric site in order to mitigate the impact caused by the construction of a phosphate mine's utility corridor. The South Prong I site (8-Hi-418) yielded data that indicates a fairly continuous occupation from Archaic through Mississippian periods. Preliminary analysis shows a continuum of projectile point types covering all these periods. However, the nature of the artifact assemblage and the concentrations of the cultural materials suggest that this site was never the loci of a large population habitation for any extended length of time. The site will be compared with other excavations in the Hillsborough, Manatee, Polk, and Hardee Four Corners Area to illustrate settlement patterning and subsistence relationships in prehistoric times.

2:15 pm ANS-64 Technological Analysis of Aboriginal Ceramics: Its Potential in Florida. JEFFREY M. MITCHEM, Department of Anthropology, 1350 GPA, University of Florida, Gainesville, FL 32611. Performing technological analyses of aboriginal Florida pottery holds much promise for answering questions involving cultural processes and change. Analyses in progress are reported and their implications discussed. The potential uses of technological analyses to demonstrate trade and interaction are assessed.

2:30 pm ANS-65 Spanish Artifacts in Calusa Florida, a Predictive Model. WILLIAM E. McGOUN, Department of Anthropology, University of Florida, Gainesville 32611. Various classes of artifacts were considered to establish a model for the assemblage that reasonably could be expected from a site connected with the 1566-1569 Spanish attempt to establish a missionary presence among the Calusa Indians of southwest Florida. The only single artifact that could be definitive is a Sacred Heart medallion of the Jesuit order, inasmuch as virtually all other Spanish missionary activity in Florida was carried on by Franciscans. Otherwise, a Spanish presence would have to be defined by a constellation of artifacts rather than any single one.

SATURDAY 2:45 pm Sage Hall, Room 205
BUSINESS MEETING: Anthropological Sciences Section
M. YASAR ISCAN, Florida Atlantic University, presiding

BIOLOGICAL SCIENCES

FRIDAY 8:15 am Sage Hall, Room 218
SESSION A: Marine Biology
FRANK E. FRIEDL, University of South Florida, presiding

8:15 am B10-66 The Grasping Appendages of Caprella penantis Leach (Amphipoda). Ralph Lombardo and R. R. Lewis, Mangrove Systems Inc., Box 24748, Tampa, Florida 33623. Caprella penantis specimens were found and collected from a Leptogorgia virgulata colony in Old Tampa Bay, Florida. The grasping appendages, maxillipeds, gnathopods, and pereopods were examined with scanning electron microscopy. The resulting micrographs showed the maxilliped and gnathopod dactyls to be highly serrate and the palm of gnathopod 1 to be toothed. Rows of scale-like plates were found present on the dactyl of pereopod 7. Preliminary live animal observations suggest that these appendages perform a variety of grasping, feeding and climbing functions. The specific use of each appendage has been defined through its ultrastructure.

8:30 am B10-67 A Freshwater Bivalve System for the In Vitro Analysis of Molluscan Nitrogen Catabolism. MICHAEL A. VITALE and F.E. FRIEDL, University of South Florida, Tampa, FL 33620. The freshwater bivalve Elliptio buckleyi has been investigated for its suitability in in vivo studies on nitrogen metabolism. Clams with one valve removed were placed into experimental chambers containing a buffered physiological salt solution with stirring. The concentrations of ammonia, urea, and ninhydrin positive materials accumulating in the ambient medium were determined. It was found that ammonia production was linearly related to time over a 12 hour experimental period. Ninhydrin positive substance loss or leakage was minimal and urea was not found. Over the periods tested, this preparation has proven stable and of value in the study of the effects of injected substances (E.G. amino acids) on nitrogen metabolism. Thus, the system should be useful in verifying the operation of catabolic pathways suggested by previous enzyme analyses.

8:45 am B10-68 Structural Differences in Male and Female Burrows of Uca pugilator. JOHN M. BECKER and GERTRUDE W. HINSCH, University of South Florida, Department of Biology, Tampa, FL 33620. It was believed that the fiddler crab, Uca pugilator, rarely digs its own burrow but during the tidal cycle moves randomly from burrow to burrow using such as a simple shelter from predators, extremes of temperature and dessication. Burrows occupied by males or females show structural differences in angle of entry, burrow length and diameter, suggesting a sex-oriented non-randomness of occupation. Male occupied burrows enter at a lesser angle, are longer and have an enlarged chamber at their deepest point. Many have hood structures and adornments at their entrances. In contrast, female occupied burrows enter almost vertically into the substrate, are shorter and have no enlarged chambers or entrance modifications. On the basis of these data we suggest that each sex of crab digs its own or occupies a burrow of the proper construction for that sex. Evidence suggests that the enlarged chamber and hood and adornment structures of the male occupied burrow may be important in courtship and reproduction.

9:00 am B10-69 Extraoral feeding in Luidia clathrata Say (Echinodermata: Asteroidea). J. B. MCCLINTOCK, T. S. KLINGER, AND J. M. LAWRENCE, Dept. of Biology, Univ. of South Florida, Tampa 33620. Members of the genus Luidia have been considered to be intraoral feeders exclusively. Luidia clathrata also feeds by everting the cardiac stomach. Of a random sample of 231 individuals in Old Tampa Bay, 32% had their stomachs extruded and applied to the substratum. Of those individuals with everted stomachs, 59% were buried in the sediment. Of these buried individuals, 62% had everted stomachs. Only 18% of the unburied individuals had everted stomachs. Organic-rich sediment promotes stomach eversion in *L. clathrata*. 59 + 13% of the starfish in an aquarium with the sediment fortified with a fine protenacious powder (1% w/w) everted their stomachs. No stomach eversion occurred when the sediment contained no organic material. Protein powder was distributed throughout the digestive system of the starfish, indicating an active movement of these particles. This alternate mode of feeding could provide a detrital food source in addition to macrophagous foods.

9:15 am B10-70 Stimulation of the pedicellariae of *Coscinasterias tenuispina* Lamarck (Echinodermata: Asteroidea). J. M. LAWRENCE, Dept. of Biology, Univ. of South Florida, Tampa 33620. The fleshy sheath of the rosettes surrounding the spines on the aboral surface were elevated by a peristaltic-like contraction progressing from the base, and the jaws of the pedicellariae on the sheath were opened when intact individuals were tactilely stimulated on the rosette spine, adjacent body wall or papulae, or on the sheath or outside of the pedicellariae jaws. The sheath and pedicellariae responded similarly with exposure of the intact individual to gastropod extract. Sheath elevation and pedicellariae opening occurred when the rosette spine of isolated aboral body wall segments and of rosette-spine preparations were tactilely stimulated, but not when they were exposed to gastropod extract. This indicates that chemoreceptors which lead to a response by the sheath and pedicellariae are not locate there. Vigorous tactile stimulation of the rosette spine produces extreme retraction of the sheath and pedicellariae. The sheaths and pedicellariae do not respond to contact with other arms of the same or different individuals.

9:30 am BREAK

9:45 am B10-71 Effect of Salinity on Levels of Intracellular Water in the Pyloric Caeca and Tube Feet of *Luidia clathrata*(Say). WALTER J. DIEHL, Dept. of Biology, Univ. of South Florida, Tampa, 33620. Using ^{14}C-polyethylene glycol, extracellular water was measured of the pyloric caeca and tube feet of *Luidia clathrata* exposed to 15, 25, 35o/ooS. Extracellular water was 6.6% and 14.8% of the tissue water of the pyloric caeca and tube feet, respectively, and did not vary with salinity. The volume(ml) of intracellular water per g wet tissue was calculated. In the pyloric caeca this increased from 0.638 ± 0.026 to 0.722 ± 0.018 after exposure to 15o/ooS for 12 hr and decreased to 0.605 ± 0.007 after exposure to 35o/ooS for 12 hr. In the tube feet this increased from 0.700 ± 0.012 to 0.756 ± 0.012 after exposure to 15 o/ooS for 12 hr and decreased to 0.684 ± 0.012 after exposure to 35o/ooS for 12 hr. After 1 week, levels of intracellular water approached control levels in both tissues exposed to 15o/ooS, but remained unchanged in both tissues exposed to 35o/ooS. The level of intracellular water must be known in order to calculate the concentrations of intracellular osmolytes.

10:00 am B10-72 The role of teloreception in the location of potential food items by *Lytechinus variegatus* Lamarck (Echinodermata: Echinoidea). T. S. KLINGER, Dept. of Biology, Univ. of South Florida, Tampa 33620. *Lytechinus variegatus* does not locate or differentiate between food items at a distance. *L. variegatus* feeds upon the sea grass *Thalassia testudinum* and the marine algae *Gracilaria verrucosa* and *Ulva lactuca* and has elective differences between them. The detection of these foods by *L. variegatus* was tested in a planar seawater system. The sea urchins did not move towards these foods; the distribution of individuals within the tank remained uniform. Prior feeding on *U. lactuca*, given *ad libitum* for one week, does not change this indifference. Even when offered the choice between food (*U. lactuca*) and no food, individuals do not move toward the potential food source. The levels of organic compounds (carbohydrates and amino acids) leached from these food sources are too low to produce a feeding response in these sea urchins. The leachates are phagostimulatory when concentrated. These data suggest that *L. variegatus* relies more upon chance encounters as a search strategy than upon teloreception.

10:15 am B10-73 High Salinity Induction of Ray Abnormalities in the Starfish Echinaster (Echinodermata: Asteroidea). STEPHEN A. WATTS, R.E. SCHEIBLING, A.G. MARSH, AND J.B. MCCLINTOCK, Dept. of Biology, Univ. of South Florida, Tampa, 33620. The etiology of ray abnormalities in echinoderms has been attributed to injury, incomplete regeneration, poor nutrition, or congenital variations. Embryos of *Echinaster* sp. (Type II) were transferred to 20, 25, 30^{o}C, and 25, 32, 39^{o}/oo forty hrs after the eggs were fertilized at 25^{o}C and 32^{o}/oo. At 39^{o}/oo at all temperatures, approximately 35% of all metamorphosed individuals had 3 or 4 rays instead of the usual 5 rays. Four-ray individuals predominated over 3-ray individuals by a ratio of 2:1. These data indicate that a physical factor such as salinity may influence ray formation during early development, and may account for some ray abnormalities observed in the field.

10:30 am B10-74 Escape response of *Argopecten irradians* (Mollusca: Bivalvia) to *Luidia clathrata* and *Echinaster* sp. (Echinodermata: Asteroidea). JAMES B. MCCLINTOCK, Dept. of Biology, Univ. of South Florida, Tampa 33620. The bivalve *Argopecten irradians* showed a strong escape response when placed in contact with *Luidia clathrata*. This response is characterized by rapid movements of the valves resulting in immediate displacement of the starfish and subesquent relocation of the bivalve. *Argopecten irradians demonstrated* only minimal levels of response when placed in contact with *Echinaster* sp. Whole-animal homogenates of the two asteroid species injected into the mantle cavity of *A. irradians* resulted in similar levels of response. The intensity of the escape response elicited by *A. irradians* may be related to the different feeding modes of these two asteroid species. *Luidia clathrata* feeds primiarily on macrofauna (e.g., bivalves, ophiuroids, and polychaetes)while *Echinaster* sp. is predominantly a microphagous feeder on detritus and encrusting organisms.

FRIDAY 9:30 am Sage Hall, hallway near Room 221
POSTER SESSION C
(NOTE: see p. 24)

FRIDAY 11:00 am Sage Hall, Room 221
BUSINESS MEETING: Biological Sciences Section
RICHARD P. WUNDERLIN, University of South Florida, presiding

FRIDAY 8:15 am Sage Hall, Room 221
SESSION B: Botany
ELIANE M. NORMAN, Stetson University, presiding

8:15 am BIO-75 Reproductive Biology of Two Species of Pawpaw, *Asimina obovata* and *A. pygmaea* (Annonaceae). DAVID CLAYTON AND ELIANE M. NORMAN, Dept. of Biology, Stetson U., DeLand, Fl 32720. Field studies of *Asimina obovata* and *A. pygmaea*, shrubs of central Florida, were undertaken to determine their phenology, breeding system, pollinators, and germination. Their flowering periods overlap, with the onset of flowering in *A. obovata* preceding that of *A. pygmaea* by two weeks. Both taxa were found to be protogynous, but *A. obovata* occasionally can self-pollinate. In control flowers of *A. obovata* only 16% set fruits while 32% set fruits in hand pollinated flowers. The results for *A. pygmaea* were 8% and 60% respectively. Hand pollination between the species produced fruits in 30% of trials. Both pawpaws are beetle pollinated. The chief pollinators of *A. obovata* are *Typocerus zebratus*, *Trichotinus rufobrunneus* and *T. lunulatus*. The main pollen vector of *A. pygmaea* is *Euphoria sepulchralis*. Evidence that pollen may be transferred between the two species was provided by one sighting of *Euphoria* in *A. obovata* and one sighting of *Trichotinus* in *A. pygmaea*. Further studies are being made.

8:30 am BIO-76 Distribution and Ecology of Six Species of the Bromeliaceae in Southern Florida. BRADLEY C. BENNETT, Department of Biological Sciences, Florida Atlantic University, Boca Raton 33431. The Bromeliaceae is represented by 3 genera in the subfamily Tillandsiodeae and 15 species in southern Florida, all of which are obligate epiphytes. Of the 15 species that are native to southern Florida 9 are common and are found in a wide range of habitats. The other 6 species have more restricted distributions. *Guzmania monostachia*, *Catopsis berteroniana* and *C. floribunda* are found in Dade, Monroe and Collier Counties. *Catopsis nutans* and *Tillandsia pruinosa* are known from only a few populations in Collier County. *Tillandsia flexuosa* is found in 7 counties in southern Florida as far north as Martin County on the east coast and Lee County on the west coast. Causes of these distributions include narrow environmental tolerances, low rates of establishment and the patchiness of the epiphytic habitat. Density-independent mortality and efficient habitat partitioning have precluded any apparent interspecific competition among these bromeliads.

8:45 am BIO-77 Preliminary Studies on the Distribution of Mangrove Bryophytes from Florida and Abaco, Bahamas. D. TeSTRAKE WAGNER-MERNER, R.B. LASSITER, J.A. LASSITER, Biology Department, University of South Florida, Tampa, FL 33620 and D.A. BREIL, Department of Natural Sciences, Longwood College, Farmville, VA 23901. In a study of 16 mangrove community sites in Florida and Abaco we found bryophytes occurring in half of the areas examined. Thus far 22 taxa of both liverworts and mosses were collected from a variety of corticolous substrates including *Rhizophora mangle* L., *Avicennia germinans* (L.) L., *Conocarpus erecta* L., *Laguncularia racemosa* Gaertn f. This study supports other observations of the occurrences of liverworts from some Florida mangroves but new taxa and new ranges were observed.

9:00 am BIO-78 Some Effects of Aponin on Fungal Spore Germination. M. HALVORSON, D. TeSTRAKE WAGNER-MERNER, Department of Biology, and D.F. MARTIN, Department of Chemistry, University of South Florida, Tampa, FL 33620. Studies on fungal spore germination of *Curvularia* sp. and *Dendryphiella salina*, were done in the presence of aponin, a substance elaborated by *Gomphosphaera aponina*, a marine blue green alga. Previous studies show that it contributes to cytolysis of three marine algae at low concentrations, <10ppm. Stimulation of spore germination was observed for *D. salina* at all concentrations of aponin used. For *Curvularia* sp. inhibition of spore germination was observed at lower concentrations while at higher concentrations stimulation was recorded. Spore age was seen to be a factor in the germination of *Curvularia* sp. but not in *D. salina*. Spore germination was also tested using cell free *G. aponina* media and natural sea water. The relationship of these results to mycostasis will be discussed.

9:15 am BIO-79 Ecological Studies on *Basidiobolus* sp., a Fungus Occurring in the Digestive Tract of Amphibians and Reptiles. JOSEPHINE I. OKAFOR, University of Nigeria, Nsukka, Nigeria, D. TeSTRAKE WAGNER-MERNER, and H.R. MUSHINSKY, Department of Biology, University of South Florida, Tampa, FL 33620. A survey of the distribution and occurrence of *Basidiobolus* from the guts of amphibians and reptiles from Florida is being made. This fungus was isolated from the intestinal feces of over 50% of the anoles and about 25% of the toads so far investigated. Sixteen anoles were kept in separate cages for periods ranging from one week to three months during which time their fecal droppings were regularly cultured on agar plates for isolation of *Basidiobolus*. Nine gave positive growth of the fungus in the first two or three droppings and none in the subsequent ones when these animals were starved. Feeding meal worms and some flies yielded no positive growth but when fed meal worms that had crawled over cultures of *Basidiobolus* some again gave positive growth. These studies support much earlier European studies.

9:30 am BREAK

9:45 am BIO-80 Preliminary Investigation of a Small South Florida Acid Marsh. JERILYN JEWETT-SMITH, CLINTON DAWES and SANDRA UPCHURCH, Department of Biology, University of South Florida, Tampa, FL 33620. A one year assessment of a small upland community acid-marsh in Hillsborough County T27S, R20E, points to the relationship to temperate *Sphagnum* bogs. The rich algal flora is dominated by green algae (Chlorophyta) primarily of the desmids *Hyalotheca dissiliens* in the fall and *Zygnema* sp. in the winter. The volvocalian greens *Chlamydomonas* spp. and *Eudorina elegans* were most abundant in spring and summer. Macrophytes underwent seasonal succession with a change from *Xyris* sp. dominant in fall 1980 to *Dicanthelium sabulorum* in fall 1981 possibly due to dessication of the marsh in spring 1981. Chemical analysis of the water shows an inverse relationship between depth and ion concentration, with a pH range of 4.4 to 5.3.

10:00 am BIO-81 Distributions of Co-dominant Tree Species in Burned Fields of Different Ages. EDWIN M. BLACK AND G. BRUCE WILLIAMSON, Department of Biology, University of South Florida, Tampa 33620. Four adjacent fields in a Florida sandhill community were burned on schedules of 1, 2, control (0), and 5 years respectively. Areas of 5250 square meters in each field were divided into two equal replicates. Within each replicate all members of the three co-dominant tree species (*Pinus palustris*, *Ouercus laevis*, and *Ouercus geminata*) were measured for diameter at breast height. Significant differences in both the size distributions and the species percentage composition in each field were found. In addition, analysis by quadratic regression of the size distributions by species on field age indicated a significant relation between burning schedule and mean tree diameter. Therefore, burning schedules may be important in determining species distributions in the Florida sandhill community.

10:15 am BIO-82 Vegetational Changes Resulting from Underground Pumping at the Cypress Creek Wellfield, Pasco County, FL. THEODORE F. ROCHOW, Southwest Florida Water Management District, 5060 U.S. Highway 41 S., Brooksville, FL 33512. For six years the vegetation and surface water levels have been monitored at Cypress Creek Wellfield. During this time water production rose from 0 to 30 million gallons per day. Pickerelweed (*Pontederia lanceolata*), Rush (*Juncus repens*) and Smartweed (*Polygonum hydropiperoides*) disappeared from certain wetlands as surface waters declined. Southern Willow (*Salix caroliniana*), Dog Fennel (*Eupatorium* sp.) and Maidencane (*Panicum hemitomon*) increased in abundance while the original vegetational zonation of the wetlands changed considerably. Vegetational changes are discussed in relation to the amount of wellfield pumping, yearly precipitation and site-specific hydrological conditions.

10:30 am BIO-83 Seagrass Species, Density and Theoretical Productivity Off Key Biscayne, Florida. F. Booker, A. Thorhaug, G. Beardsley and B. Flynn, Applied Marine Ecological Services, 600 Grapetree Dr., Key Biscayne, FL 33149. A crescent-shaped seagrass bed of approximately 648 ha off Key Biscayne, Florida was surveyed by divers every 5 m along 7 transects which ran perpendicularly from the grass line near shore out to 100 m. Three species of seagrasses dominated the bed: *Thalassia testidinum*, *Syringodium filiforme* and *Halodule wrightii*. The mean density ($\bar{x}$ ± S.E. blades/m^2) and derived productivity (gC/m^2/day) for *T. testidinum* was 348.3 ± 24.1 blades/m^2 and .2 gC/m^2/day (Thorhaug and Roessler 1979); *S. filiforme* was 394.1 ± 52.8 blades/m^2 and .1 gC/m^2/day (Zieman and Wetzel 1980); and *H. wrightii* was 231.9 ± 123.1 blades/m^2 and >.01 gC/m^2/day (Dylan 1971). A survey of grasses farther offshore was made along 3 transects which ran from 100 m offshore out to 250 m offshore. The density and productivity was less offshore: *T. testidinum* was 175.0 ± 27.9 blades/m^2 and .1 gC/m^2/day; *S. filiforme* was 94.0 ± 42.1 blades/m^2 and .03 gC/m^2/day; and *H. wrightii* was 15.0 blades/m^2 and >.001 gC/m^2/day.

10:45 am BIO-84 Electron microscopy of Epiphytes on the Marine Alga *Dictyota*. JEANETTE M. RHEINHARDT AND HENRY C. ALDRICH, University of Florida, Gainesville 32611. *Dictyota*, a macrophytic alga common in Florida coastal waters, may possibly provide biomass for production of methane. Using scanning and transmission electron microscopy and epi-fluorescence UV microscopy, we have examined its surface for epiphytes to determine whether significant interference with algal growth derives from that source. Both field collections and cultured plants were examined. Diatoms, bacteria, blue-green algae, filamentous red algae, fungi, and protozoa all colonize Dictyota, producing a significant coating on its surfaces. Wall degradation was seen frequently, and algal growth could be considerably reduced by shading of its photosynthetic apparatus by these epiphytes.

FRIDAY 9:30 am Sage Hall, hallway near Room 221
POSTER SESSION C
(NOTE: the following paper will be on display from 9:30 am to 4:15 pm)

9:30 am BIO-85 Wet Depression Floristic Survey. JEAN HUFFMAN, BETH HUSSEY, GREG BALKE, AND GROVER CHAMPION, Environmental Studies Program, New College-USF, 5700 N. Tamiami Trail, Box 89, Sarasota 33580.

FRIDAY 11:00 am Sage Hall, Room 221
BUSINESS MEETING: Biological Sciences Section
RICHARD P. WUNDERLIN, University of South Florida, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 2:45 pm Sage Hall, Room 221
SESSION D: Ecology and Evolution
TERRY W. SNELL, University of Tampa, presiding

2:45 pm BIO-86 The Comparative Use of Food and Space by Three Bahamian Butterflyfishes. PATRICK A. PITTS AND W.S.ALEVIZON, Florida Institute of Technology, Melbourne, FL 32901. The use of food and space resources were compared among three butterflyfishes (Chaetodon capistratus, C. striatus, and C. ocellatus) inhabiting the same general Bahamian coral reef environment. These fish showed significant differences in their distribution and abundance patterns. Two species, C. striatus and C. ocellatus, displayed an almost perfect inverse correlation in abundance among the five reef "zones" investigated. The diets of these two were found to overlap extensively. The third species, C. capistratus, was found to broadly overlap the other two species in its use of space resources, but showed distinct differences in its use of food resources. The data supports the traditional view that coral reef fishes tend to avoid or reduce competition by specializations which enable them to partition available food and space resources.

3:00 pm BIO-87 House Wren Migration Compared with other Wrens: An Emphasis on Florida. WALTER KINGSLEY TAYLOR AND MARK A. KERSHNER, Department of Biological Sciences, University of Central Florida, Orlando, Fl 32816. Data obtained on 6 eastern United States wren species were reviewed for migratory analysis. A total of 8,751 autumn migrants contributes to the data base, with 6,922 individuals from annual banding operations and 1,829 individuals killed at tall, lighted structures and at airport ceilometers. Three species, House (*Troglodytes aedon*), Long-billed Marsh (*Cistothorus palustris*) and Short-billed Marsh (*C. platensis*) were evaluated in more depth. The House Wren is a more common migrant in the peninsula than in the panhandle region. This is probably true for both marsh wrens. For the 3 species, weights for all age-sex classes are congruous and females outnumbered males. The peak of migration in central Florida is in mid-October. House Wrens show considerable site fidelity; some individuals probably follow the same migration route year after year.

3:15 pm BIO-88 Multiple Nest Construction by Limpkins (*Aramus guarauna*) for Rearing Their Young. MICHAEL BROTHERS and DAVID STOCK, Museum of Arts and Sciences, Daytona Beach, FL and Dept. of Biology, Stetson Univ., DeLand, FL 32720. Some species in the crane and rail families of birds construct egg nests and a second type, the "brood" nest, to rear their young. Limpkins, long legged wading birds found in swamps throughout peninsular Florida, resemble the cranes and the rails, but are classified in a family by themselves. Like their relatives, the cranes and the rails, limpkins may construct more than one type of nest to rear young. Use of four types of nests have been observed. Egg nests cradle eggs until abandoned by the chicks shortly after hatching. Young chicks are collected on "brood" nests that are constructed nightly. Threat of danger may induce parents to construct a "concealment" nest. If parents begin incubating a second clutch of eggs prior to maturity of the first brood, an "adolescent" nest may be constructed. The limpkin is the only bird known to construct so many types of nests during rearing of the young.

3:30 pm BIO-89 Distribution and status of alligators and crocodiles in the lower Florida Keys. TERRI JACOBSEN, South Florida Research Center, Everglades National Park, Homestead 33030. The protection and management of wildlife habitat by the National Wildlife Refuge System has enhanced survival prospects for a small, isolated population of alligators in the lower Florida Keys despite the continued loss and fragmentation of suitable habitat by development. No current self-sustaining population of crocodiles appears to exist in the area although transient individuals occassionally occur there. Data are not available to evaluate historical trends in population status, although the seasonally stressful environment and the limited availability of suitable nesting habitat suggest that alligators and crocodiles have not at any time occurred in greater numbers in the lower Keys. Supported in part by a grant from Sigma XI.

3:45 pm BIO-90 Observations on the ecology of benthic aquatic testaceans (Protozoa, Rhizopoda, Testacealobosia). HAYDEE LENA Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL 32901.
Living testaceans from sediments of benthic samples of South and North America were correlated with environmental parameters (temperature, salinity, water depth and substrate). The samples were collected with bottom scrapers and core samplers and were fixed with 10% formalin. Later, the samples were treated using standard foraminiferologic methods. These methods for obtaining testaceans permitted the easy separation of numerous specimens and empty shells. It was found that different types of environments support a unique combination of testacean species. The distribution, abundance, shell ornamentation, shell composition and morphologic type of the shell of each species are related to the type of substrate and water depth rather than temperature. Living testaceans were not found deeper than 6 cm in core samples. The optimal salinity for testaceans is 1-2%, but isolated living specimens were found in waters with 25% salinity.

4:00 pm BREAK

4:15 pm BIO-91 Patterns of Sexual Reproduction in Rotifers. CHARLES J. BIEBERICH AND T. W. SNELL, Division of Science, University of Tampa, Tampa, FL 33606. The pattern of mictic (sexual) daughter production in the saltwater rotifer Brachionus plicatilis was investigated. Life table experiments suggested two models to explain the change from asexual to sexual reproduction. Both an induction model and an inhibitor-release model are presented. In females that produced mictic offspring, 14% of all daughters were mictic. The adaptive significance of this level of sexual reproduction is discussed.

4:30 pm BIO-92 Feeding Ecology of the Mangrove Tree Crab Aratus pisonii (Milne Edwards): Selection of Older Leaves for Herbivory. ROBERT A. MATTSON, Dept. of Biology, University of South Florida, Tampa 33620. The feeding ecology of the arboreal mangrove grapsid Aratus pisonii (Milne Edwards) is as yet incompletely characterized. It has generally been listed as a primary herbivore, live mangrove leaves forming the principal component of its diet. In some populations live leaves seem to form a less important part of the diet, decaying wood and leaves, epiphytic algae, and detritus being more important. Crabs from these latter populations, however, do show a preference in herbivory of live leaves. Laboratory studies showed that older leaves (those further down on the stem) are consumed to a significantly greater extent than younger, more recently unfurled leaves. This preference cannot be attributed to water content, as no significant differences were found between older and younger leaves with respect to this factor.

4:45 pm BIO-93 Ecological Observations on the Polychaete Onuphis simoni in Tampa Bay, Florida. HWEY-LIAN HSIEH and JOSEPH L. SIMON, Department of Biology, University of South Florida, Tampa, FL 33620. The polychaete Onuphis simoni Santos, Day & Rice in the intertidal zone of Tampa Bay, Florida, had higher population densities (3370 individuals/m^2) in areas vegetated with the seagrass Halodule wrightii Aschers than in unvegetated areas (200 individuals/m^2). The density of young (larvae plus juveniles) showed a positive linear relationship with adult density ($Y=5.57 + 2.74X$; $r=0.87$). Larvae were brooded within the parent's tube while juveniles initially built tubes attached to that of the mother. At one study site, density was under 300 individuals/m^2 from 1968 to 1972, then increased exponentially from 30 to over 2000 individuals/m^2 between 1976 and 1981. The relationship between population growth and reproductive biology in O. simoni is under investigation.

5:00 pm BIO-94 Macroinvertebrate Infauna of a Salt Marsh Tidal Creek. RONALD G. HORLICK AND C. B. SUBRAHMANYAM, Saline Marsh Ecology Program, Florida A & M University, Tallahassee, FL 32307. Tidal creeks are integral parts of salt marsh systems, and serve as channels for transportation of fauna and materials between marshes and estuaries during tidal cycling. Spatial and temporal distributions of benthic infauna in a north Florida tidal creek were studied for a year. A total of 111 species and 6,069 individuals were found at four sites that were equidistantly located along the creek. Highest abundance and species numbers were noticed at the creek mouth, the lowest at the creek origin, and the decreasing gradient of these two parameters along the creek as statistically significant. Adjacent stations shared more common species than stations further apart. Fauna of the creek mouth was more similar to that of the estuary, and fauna at the origin was more similar to that of the marsh. These results suggest that tidal creeks act as ecotones between salt marshes and estuaries.

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

SATURDAY 9:00 am Sage Hall, Room 218
SESSION E: Zoology
WAYNE PRICE, University of Tampa, presiding

9:00 am B10-95 Biology of the Bull Shark in the Indian River Lagoon, Florida. FRANKLIN F. SNELSON, JR. AND TIMOTHY J. MULLIGAN, Dept. Biological Sciences, Univ. Central Florida, Orlando 32816. The bull shark, *Carcharhinus leucas*, is the most common shark in the brackish Indian River lagoon system on the central east coast of Florida. The biology of the lagoon population was studied between May 1975 and May 1979. Pregnant females, 240-265 cm long, move into the lagoons in the spring and early summer and give birth in June and July to young that average about 75 cm long. The females leave the lagoons after parturition. Young and juvenile sharks stay in the lagoons for about 3 years, until they are 180-200 cm long. There may be some emigration from the lagoons in winter, especially in yearlings. Subadult sharks leave the lagoons permanently as they begin to mature, and join the population of adults that apparently resides in deeper offshore waters. Juvenile bull sharks in the lagoon system feed primarily on stingrays and marine catfishes.

9:15 am B10-96 Coral Reef Fish Communities: Effects of Predator Removal. JAMES A. BOHNSACK, Cooperative Institute for Marine and Atmospheric Sciences, University of Miami, 4600 Rickenbacker Causeway, Miami 33149. The hypothesis that piscivorous predators control coral reef fish community structure was experimentally tested in the Florida Keys. Random visual censuses were made for one year on large control and experimental reefs. The experimental reef, Looe Key Reef, has been continually exploited by heavy spearfishing pressure which is particularly effective at removing the top predators. Control reefs in the Key Largo Coral Reef Preserve have been protected from spearfishing since 1960. Data show significantly fewer piscivorous predators present on the experimental reef, although one grouper, *Epinephelus cruentatus*, normally too small to spear, appeared to show some density compensation. Several non-piscivorous predator species showed significant abundance differences between experimental and control reefs. More rigorous testing of the hypothesis is currently underway. Research was supported by NOAA.

9:30 am B10-97 Diel Variation in Seagrass Bed Fish Populations. R. GRANT GILMORE AND CHRISTOPHER J. DONOHOE, Harbor Branch Foundation, Rt. 1, Box 196, Ft. Pierce, FL 33450. During 1976, 1977 and 1978, one hundred and two 10 m^2 drop net and twenty four 1,160 m^2 seine samples were taken in seagrass beds to determine the numerical abundance of fishes during diurnal and nocturnal periods. Fishes were classified into various groups based on diel changes in occurrence, abundance, and distribution (degree of clumping or patchiness). Of the 82 species captured, 46 had low enough occurrence values to be considered non-residents. Thirteen species were semi-resident while 23 were considered residents. Twelve (33%) resident and semi resident species had both higher occurrence values and greater numbers during nocturnal periods. When schooling planktivores are excluded from the calculations, a greater number of species were numerically more abundant at night.

9:45 am B10-98 Identity of the Sciaenids, Dumpy Croakers and Bullnose Spot in North Carolina. FRANK J. SCHWARTZ AND M. PROVANCHA, Institute of Marine Sciences, University of North Carolina, Morehead City, NC 28557. An intensive trawl study (1973-1980) of the estuarine Cape Fear River and adjacent Atlantic Ocean yielded 28 dumpy croakers (DS) and 22 bullnose spot (BS). Eight BS are also known from Pamlico Sound and Carteret County, N. C. Meristic, morphometric, ratio, cumulative ratio, and hybrid indexes failed to substantiate hybridization of the 2+ yr old fish. Radiographs revealed partial and deformed or fused vertebra or vertebral columns, although total vertebral counts (25) matched those for croakers and spot. Damage was usually confined to the last 13 vertebra in DS and the anterior 12 in BS. Vertebral alterations shortened the body and affected body depth and associated scale counts. Croakers and spot are fall-winter offshore spawners. Apparently environmental perturbations, such as sudden drops in water temperatures, caused the deformities in developing eggs or larvae. These events must have preceded the coldest water conditions noted for the Cape Fear estuary and elsewhere in 1976 and 1977.

10:00 am B10-99 A Comparison of the Flora and Fauna of Open and Closed Marsh Mosquito Impoundments of the Indian River Lagoon.
R. GRANT GILMORE AND DOUG COOKE, Harbor Branch Foundation, Rt. 1, Box 196, Ft. Pierce, FL 33450. Monthly collections of fishes were made in two marsh impoundments: one closed to tidal influence and the other opened to estuarine exchange through a single 80 cm culvert. Even though the tidally flooded impoundment was found to have a wide variation of physical parameters, they were not as great as those of the impounded marsh. Twelve species were collected from the flooded impoundment with only four species surviving the extreme evironmental conditions. In contrast the opened impoundment demonstrates extensive regrowth of marsh vegetation replenishing marsh diversity with 41 species represented. Currently biweekly collections in an open impoundment are being made to determine recolonization of a greater portion of the marsh flora and fauna (i.e. vegetation, macrocrustaceans, zooplankton, and mosquito populations).

10:15 am BREAK

10:30 am B10-100 Live Capture, Marking and Resighting of Free-Ranging Tursiops truncatus in the Indian River Lagoon System, Florida. JANE A. PROVANCHA, E. ASPER, Hubbs-Sea World Res. Inst. Orlando, FL 32809 and D. ODELL, Univ. of Miami, Miami, FL 33149. A 15-month study of free-ranging Tursiops truncatus in the Indian River lagoon system was initiated in December 1980. The study focuses on herd composition, movements and sociality of 109 (48 females, 61 males) cryogenically marked dolphins. A variety of biological data was collected from each dolphin prior to release. During biweekly boat surveys branded and other naturally marked dolphins were located and photographed. Observations were made on all dolphins encountered. Results suggest that the animals are year-round residents. Although several pairs of individuals were consistently seen together, herd structure is dynamic. Calving occurred year-round with a peak in the spring. Feeding strategies were both cooperative and individual. Funding and technical assistance were provided by NMFS contract #NA80-GA-C-00063 and Sea World of Florida.

10:45 am B10-101 A Technique for Improved Fixation of the Inner Ear of Young Chicks. JOSEPH V. OTTO AND J. C. PARK, Dept. Biological Sciences, Fla. Institute of Technology, Melbourne, 32901. Fixation of the inner ear tissues has always been difficult due to the bony structure encasing it. We have overcome this problem by continuously aerating the fixative with atmospheric O_2 and utilizing quick, penetration techniques to achieve improved tissue preservation with minimal distortion. Five steps are required for rapid, thorough penetration of the fixative into the inner ear organs: (1) division (mid-sagittal) of the head: (2) brain removal to expose the bony canal: (3) injection of cold, aerated fixative (4°C, buffered gluteraldehyde): (4) isolation of the inner ear through trimming procedures: and (5) aeration of the trimmed specimen. This technique is superior to current methods because it quickly delivers the fixative to the inner ear tissue, thereby preserving cellular structure. Hence, this procedure is easy to perform and provides excellent preservation for cytological studies of the inner ear. Supported in part by Sigma Xi grant awarded to J. C. Park.

11:00 am B10-102 A Survey of the Intestinal Helminths of the Cuban Anole, Anolis sagrei sagrei. WAYNE PRICE, Department of Biology, University of Tampa, Tampa, FL 33606 and HAROLD UNDERWOOD, Department of Biology, Texas A&M University, College Station, TX 77843. One hundred and one cuban anoles, Anolis s. sagrei, were collected from residential areas of Tampa, FL from May-October, 1981 and examined for intestinal helminth parasites. Sixty (59.4%) hosts were infected with at least one of the three endohelminth species recovered.

Two nematode and one digenetic trematode species were recovered. Cyrtosomum scelopori (Nematoda: Oxyurata) was recovered from the intestines of 36 (35.6%) hosts with mean intensity of infection of 96.9 worms. Physaloptera squamatae (Nematoda: Spirurata) was recovered from the stomachs of 56 (55.4%) hosts with a mean intensity of 19.1 worms. Mesocoelium monas (Trematoda: Brachycoeliidae) was recovered from the intestines of 10 (9.9%) hosts and had a mean intensity of 3.5 worms. Incidence and intensity of nematode infections generally increased with increasing host length. Mesocoelium monas infection was confined to larger hosts (35-60mm, SV length).

11:15 am B10-103 The Dynamics of Siamese Twin Formation in the Pond Snail, Lymnaea palustris. MICHAEL D. CALINSKI, New College, USF, 5700 N. Tamiami Tr., Sarasota 33580. A simple system has been developed to fuse L. palustris embryos together using centrifugation. The only stage of development in which fusion was possible was from hatching blastula (shedding of the vitelline membrane) through gastrulation (up to placoid gastrula). It is postulated that the actual mechanism of initial fusion may be related to pinosome activity at this stage of development. The configuration and extent of fusion, i.e., twins fused head to head or twins with a single body and 2, 3, or 4 heads, is probably dependent on the axis and orientation of initial fusion as is related to the presumptive developmental fate map of the blastula embryo. Possible implications concerning human siamese twin formation is discussed.

11:30 am B10-104 Feeding and growth of Asellus aquaticus (Crustacea: Isopoda) on green plant tissue in the English Lake District. JEFFRY H. MARCUS, Dept. of Biology, Florida International Univ., Tamiami Campus, Miami, FL 33199. In the laboratory, Asellus fed on small sprigs of green Elodea canadensis and had a significantly higher ($P<0.05$) mean specific growth rate ($\overline{G}$, % per day) in comparison to growth on other diets normally associated with benthic crustaceans, e.g. allocthonous leaf material, bacteria and fungi.

In the field, Asellus aquaticus was collected from the English Lake District and examined by incident-light fluorescence microscopy, and also by dissection of the gut. Green vascular plant tissue and the distinctive epidermal hair of Elodea were found in the guts of 7-39% of the Asellus examined. The use of microscopy is a valuable aid for screening invertebtates which may have eaten live plant tissue.

This work was done at the excellent facilities of the Freshwater Biological Association, Cumbia, England.

SATURDAY 9:00 am Sage Hall, Room 221
SESSION F: Environmental and Economic Biology
PATRICIA M. DOORIS, Southwest Florida Water Management District, presiding

9:00 am B10-105 Tampa Bypass Canal: Environmental Description and Habitat Quality Evaluation. VINCENT J. ATTARDI, P. M. DOORIS, M. LOPEZ. Southwest Florida Water Management District, Brooksville, FL 33512. The Tampa Bypass Canal, under construction since 1966, is now a major surface water feature in Hillsborough County. Investigations conducted since 1971 have documented the development of aquatic habitat on the Canal, and this paper will describe the (1) establishment in the Canal of emergent and submergent plant species, (2) chemical characteristics of Canal water, and (3) fish species, including exotics, present in the Canal. Utilization of the Canal by other vertebrate species particularly birds, will be mentioned. A comparison of the Canal with the Hillsborough River (connected to the Canal at two points) will be made dealing with selected chemical parameters and observed exotic fish species.

9:15 am B10-106 **The Effects of Mosquito Control Ditching on a Southwest Florida Mangrove Ecosystem. Barbara J. Conmy, New College of Univ. of S. Fla., 5700 N. Tamiami Tr., Sarasota, 33580. While the necessity for controlling salt marsh mosquitoes is generally recognized in Florida, concern for environmental quality and the conservation of natural resources has caused certain operations employed for mosquito control to become a controversial issue. Mangrove swamps are an important natural resource and are essential to maintaining the quality of Florida's coastal environment. The purpose of this study was to assess the effects of a grid-system of mosquito control ditching on a fringe mangrove swamp. Research focused on a comparison of ditched vs. unditched areas of the swamp with regard to mangrove primary productivity, community structure, and soil salinity. As the study is still in progress, but near completion, research results will be forthcoming.**

9:30 am B10-107 In vitro Growth of Hydrilla verticillata in Lake Water. P. M. DOORIS, Southwest Florida Water Management District, Brooksville, FL 33512; G. M. DOORIS, Div. Science and Math., St. Leo College, St. Leo, FL 33574; D. F. MARTIN, CHEMS Center, U. of South Florida, Tampa, FL 33620. Water from 30 lakes in central Florida was tested for the ability to support the growth of Hydrilla verticillata in vitro. Hydrilla growth, as measured by changes in fresh wet weight, revealed significant differences among the lakes. Test results are interpreted in view of the lakes' chemical characteristics and actual hydrilla presence. This work has implications for identifying environmental factors influencing the growth of hydrilla.

9:45 am B10-108 Effects of P and N Concentration in Everglades Water on Nutrient Uptake by Sawgrass and Cattail Litter in the Laboratory. NANCY H. URBAN AND PAMELA B. REEDER, South Florida Water Management District, P.O. Box V, West Palm Beach, FL 33402. A four-day laboratory experiment tested the effects of P and N concentrations in Everglades surface water on nutrient uptake by sawgrass (Cladium jamaicense) and cattail (Typha spp.) leaf litter. Uptake of P and N increased with higher concentrations in the water. Initial total N levels of 7.85 mg/l were reduced to 5.05 mg/l by sawgrass and 3.80 mg/l by cattail. Lesser reductions occurred when initial concentrations were 5.95 mg/l, 3.84 mg/l and 2.88 mg/l. Initial total P levels of 1.142 mg/l were reduced to 0.798 mg/l and 0.741 mg/l by sawgrass and cattail litter respectively. Lesser reductions occurred when initial concentrations were 0.888 mg/l, 0.651 mg/l and 0.004 mg/l. The two lower initial total N levels and the lowest initial total P level showed negligible reductions. These results agree with those of field litterbag studies which measured nutrient uptake over a one-year period.

10:00 am B10-109 Quality of Retail Smoked Mullet (Mugil cephalus) in Florida. R. J. ALVAREZ, PH.D., GIBCO Laboratories, Division of The Dexter Corporation, 2801 Industrial Drive, Madison, WI 53713. Very little information is available on the literature or the microbiological quality and safety of retail smoked mullet. Samples of retail mullet were obtained from the East and West Coasts of Florida. Commercial samples were analyzed for bacterial and fungal counts, coliforms, coagulase positive Staphylococcus, Vibrio parahaemolyticus, percent WPS and phenols. Bacterial and fungal counts ranged from 9.9×10^1 to 1.2×10^{10} and 0 to 810 organisms/gram, respectively. Several potential pathogens were recovered. These included: P. aeruginosa, S. aureus, V. parahaemolyticus, E. coli and S. marcescens. Thirty-five percent of the commercial mullet was not refrigerated at the time of purchase. Percent WPS and phenols content ranged from 1.39 to 9.13 percent and 0.32 to 7.20

mg phenols/10 gm sample, respectively. The recovery of various pathogens and the presence of high bacterial levels point to the potential health hazard that could exist in currently marketed smoked mullet.

10:15 am BREAK

10:30 am B10-110 Microbiological Quality of Selected Ready-to-Eat Seafood Products. RICARDO J. ALVAREZ, PH.D., GIBCO Laboratories, Division of The Dexter Corporation, 2801 Industrial Drive, Madison, WI 53713. The microbiological quality of forty retail ready-to-eat seafood products obtained in North-Central Florida was monitored. Aerobic plate counts, yeast and molds count, coliforms, *Staphylococcus aureus*, *Salmonella*, *Vibrio parahaemolyticus*, *Clostridium perfringens* and pH were determined in crab meat, shrimp. spreads, dips, smoked seafoods, lobster, herring, sauces, oysters, conch, mackarel, mullet, salmon, crawfish, seafood seasonings and dressings. Aerobic plate counts and fungal counts ranged from 30 to 3.4 x 10^6 organisms/gram and 10 to 6.2 x 10^4 organisms/gram, respectively. No *Salmonella*, *V. parahaemolyticus* were recovered. *Clostridium* species were only present in 3 samples. *S. aureus* counts were found in acceptable limits. The microbiological quality of these seafood products was found to be generally acceptable.

10:45 am B10-111 The effect of lead acetate and lead nitrate on The growth of *Lemna minor* L. (Duckweed). SCHWEBEL, JOAN O. and KATHLEEN ANDERSON. Bethune-Cookman College, 640 Second Avenue, Daytona Beach, FL 32015. Duckweed, Lemna minor, was grown in modified Hoaglands' Solution and treated with varying concentrations (.05, 1.0, and 1.5 mg/L) of lead acetate - $Pb\ (C_2H_3O_2)_2 \cdot 3H_2O$ - and lead nitrate - $Pb\ (NO_3)_2$, Experimental plants were compared with controls, and results indicate a toxicity to lead-most marked when lead is combined in The Acetate form.

11:00 am B10-112 The Future of Lobster Farming in Florida. MICHAEL D. CALINSKI, New College, USF, 5700 N. Tamiami Tr., Sarasota 33580. Self contained prototype nursery habitats designed to attract and culture puerulus stage spiny lobsters, *Panulirus argus*, in the wild have been successfully tested on a small scale. Tag recapture data indicates that settled postlarvae, 7 mm cl, attain a size in which they can leave the nursery, 21 mm cl, in 2½ to 3 months. Survival from postlarvae to post-nursery was about 20 percent. A 100 percent tagged return was recorded. Based on a 5 percent survival for nursery growout, and based on 2½ years of puerulus settlement data collected by Fla. Dept. of Nat. Resources, 2 square kilometers of this nursery habitat could theoretically inject enough juveniles into the fishery to produce 6 to 7 million (pounds) adults annually. This would represent more than a doubling of the present fishery, and more than 17 million additional dollars into Florida's economy.

11:15 am B10-113 Variation Among Strains of the Rotifer *Brachionus plicatilis*. KELLY CARRILLO AND TERRY W. SNELL, University of Tampa, Division of Science, Tampa 33606. The saltwater rotifer *Brachionus plicatilis* is an important food source for the rearing of larval fish and crustacea. Different rotifer strains possess different characteristics that effect their suitability for use in aquaculture. Comparisons among 14 rotifer strains from various parts of the world included body size, which ranged from 123u to 291u in length, the effect of diet on body size, the relationships between trophi size and body size, and the change in size of an individual over its lifespan. Reproductive rates were also compared and substantial differences in doubling times are reported.

ENGINEERING

FRIDAY 11:00 am Sage Hall, Room 218
BUSINESS MEETING: Engineering Section
FAISSAL A. MOSLEHY, University of Central Florida, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 2:45 pm Sage Hall, Room 218
FAISSAL A. MOSLEHY, University of Central Florida, presiding

2:45 pm ENG-114 Transient and Steady State Equivalence of Dynamic Systems. SAYED M. METWALLI, Visiting Associate Professor, University of Central Florida, Orlando, Florida 32816. In this paper a new technique is presented through which transient solution can be obtained from steady state spectral response. The complete steady state spectrum should be known to evaluate its equivalent transient response. On the other hand steady state spectrum can also be obtained from transient equivalent. This process makes it possible to work with either transient analysis or steady state analysis and then perform a transformation to the other equivalent. This work has been supported in part by grant number 21-1699-035 from UCF-EIES.

3:00 pm ENG-115 Metal Fatigue in Engineering Design. A. HENRY HAGEDOORN, University of Central Florida, P.O. Box 25000, Orlando 32816. Over the last decade the design engineer has achieved in his calculations the capability of dealing with the fracture and fatigue properties of materials containing cracks.
This paper reviews the metal fatigue design methodology integrating linear elastic fracture mechanics (LEFM) with notch-strain analysis and S-N methodology to predict the fatigue resistance or fatigue life of metal parts and structures with emphasis on the applied engineering aspects.

3:15 pm ENG-116 The Method of Boundary-Integral Equation: A Simple and Efficient Tool for Solving Applied Mechanics Problems. FAISSAL A. MOSLEHY, Department of Mechanical Engineering and Aerospace Sciences, University of Central Florida, Orlando 32816. The boundary integral equation (BEI) method, with its origin in potential theory and classical elasticity, has only in recent years been developed and applied to solve significant problems in applied mechanics. The BIE is one of a class of boundary solution methods which has the advantage of modeling the boundary data, rather than the interior data, with the result that problem size is reduced, and the interior solution may be obtained with great resolution at any desired location.
This paper reviews the essential, analytical and numerical formulation of the BIE method. Several examples are presented to illustrate the application of the method to problems of heat transfer, linear elasticity, and fracture mechanics. Comparison between the BIE method and the finite element method is also discussed.

3:30 pm ENG-117 Project Management under Resource Constraints, YASSER A. HOSNI, University of Central Florida, P.O. Box 25000, Orlando, Florida 32816. In project scheduling by network analysis traditional critical path methods fail to include resource considerations. Other methods must be used to allow for resource constraints. This paper presents some computer search heuristics that generally give good results. The algorithms covers the three distinct categories (1) time/cost trade off, (2) resource leveling (3) constrained resources.

3:45 pm ENG-118 Computerized Model for Production Facilities layout Evaluation, JAMES ANDERSON, YASSER A. HOSNI, University of Central Florida, P. O. Box 25000, Florida 32816. A computer model is built to evaluate production plant layouts, in relation to the operational sequences of the products to be manufactured. The criteria to be evaluated is the proximity between production departments to minimize the material handling operations. The model is operational on a microcomputer with simple techniques in data entry. The algorithm used in the model adhears to the standards used by Industrial Engineering (IE) practitioners. IE's can use the model to suggest/evaluate alternative designs, a process which is computationally exhaustive; before the implementation phase.

4:00 pm BREAK

4:15 pm ENG-119 Monitoring and evaluation systems for energy conservation measures in Florida residence, ROBERT D. DOERING, YASSER A. HOSNI, University of Central Florida, PO Box 25000, Orlando, Fl. 32816. Florida climate differs widely from other States. Consequently some energy conservation measures are new/unique and lack evaluation. UCF was awarded a research contract by Florida PSC to evaluate specific energy conservation measures when implemented in typical Florida residences. While the project is being conducted, the process of residence choice, design of the computer system for data collection, and the design of the evaluation model; has been completed.

The authors will present the energy conservation measures being implemented, method of data collection and the models to be used in the evaluation process.

4:30 pm ENG-120 Heavy Metals in Floodplains Receiving Highway Bridge Runoff. ELIZABETH T. SKENE, HARVEY H. HARPER AND YOUSEF A. YOUSEF, Department of Civil Engineering and Environmental Sciences, University of Central Florida, Orlando, Florida 32816. A study was supported by Florida DOT and SUS/STAR to investigate the fate of heavy metals in bridge runoff which are received by surrounding floodplains. Three various bridge sites in Central Florida were selected and various locations in each site were sampled. The soil and plant samples from floodplains were tested for their ability to retain and release heavy metals, particularly Pb, Zn, Fe, Ni, Cu, Cd and Cr.

Batch experiments were also designed to investigate the sorption-desorption properties of the soil. Soil capacity for lead increased with increasing pH, organic content and soil buffering capacity. Also, information about speciation of heavy metals in a floodplain was detected using various extraction solutions.

4:45 pm ENG-121 Continuous Harvest and Sorting Methods for the Freshwater Prawn, Macrobrachium rosenbergii. PETER W. HILL, College of Engineering, University of South Florida, Tampa 33620. Exploitation of the natural biological response of prawns to water currents has laid the foundation for an automatic sorting and harvest system. Preliminary gradation experiments have shown that a size gradient can be established when prawns are subjected to a controlled water current flowing over a special ramp. Sorting is achieved through an adjustable step in the ramp, using thoracic diameter as an index for separation. A successful bench scale separator has been tested and based on results, a post-larvae separator and a pond separation and harvest process have been proposed.

5:00 pm ENG-122 Determination of Optimum Timing Aperture and Random Correction in Positron Emission Tomography. THEODORE J. STRICKLAND, Baumritter Institute of Nuclear Medicine, Mount Sinai Medical Center, 4300 Alton Rd., Miami Beach, Fl. 33140. Positron Emission Tomography (PET) is a method for measuring the in vivo distribution of a positron-emitting isotope in the brain. PET utilizes time-coincident photons emitted 180^{o} apart during positron annihilation. The scanner detects these photons and reconstructs them into two-dimensional tomographic images. The optimum timing aperture was determined by using the data from four separate investigations. Count rates were varied by using 2, 5, 10, and 20 millicuries of fluorine-18. Ten data points at two nanosecond (nS) increments from 6-22nS were taken. The data from the scans was time corrected to compensate for decay of the isotope and plotted as a function of aperture width. The curves indicated the optimum aperture width was 13 nS (± 1 nS). The investigations also indicated that the PET system's method of random correction undercorrects the data. A random occurs when unrelated photons intercept a crystal pair. Various random correction methods have been investigated.

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

ENVIRONMENTAL CHEMISTRY

FRIDAY 10:00 am Sage Hall, Room 102
SESSION A
RICHARD H. PIERCE, Mote Marine Laboratory, presiding

10:00 am ENV-123 Analysis of Diverse Biological Activities of Materials Elaborated by a Marine Blue-green Alga Gomphosphaeria Aponina. RALPH E. MOON AND DEAN F. MARTIN, CHEMS Center, Department of Chemistry, University of South Florida, Tampa, FL 33620. Chemicals elaborated by the blue-green alga were extracted from cultures with chloroform, and subjected to reverse-phase HPLC. Some 29 components were collected, and were characterized by following bioassays: cytolysis (against Ptychodiscus brevis), antifungal activity (against yeast, Saccharomyces cerevisiae), and germination (using lettuce seeds). The activities of individual fractions are compared. The germination test is a particularly convenient method for monitoring allepathic substances from complex mixtures.

10:30 am ENV-124 Response of Hydrilla to Selected Dyes. JOHN BARLTROP, BARBARA B. MARTIN, AND DEAN F. MARTIN, CHEMS Center, Department of Chemistry, University of South Florida, Tampa, FL 33620. The perennial submersed noxious aquatic plant Hydrilla verticillata (Royle) was treated with well water solutions of methylene blue, hematoporphyrin, and Eosin Y, and compared with control systems. Statistically significant reductions in growth were observed for treatments with all three dyes at initial dye concentrations of 10^{-4} M. Typically, reductions in growth of 30 percent on a relative basis for the test systems were observed. Methylene blue was absorbed onto the plant, raising the possibility that shading could be affecting plant growth. Similar adsorption was not noted for the other two dyes. Though two dyes are used as redox indicators, the third -- hematoporphyrin -- is not, and a common mechanism of action may be proposed: that the dyes are involved in photodynamic action. It is possible that natural products may act in a similar manner to manage hydrilla through photodynamic action, and the implications of this hypothesis are considered.

10:45 am ENV-125 The Degradation of the Pesticide Ethion in Florida Canal Waters. R.J.PFEUFFER AND F. DIERBERG, Dept. of Environmental Science and Engineering, Florida Institute of Technology, Melbourne, FL 32901. The degradation of the organophosphorous pesticide (0,0,0',0', tetraethyl-S,S'-methylenebisphosphorodithioate) was determined for sterilized and unsterilized orange grove irrigation canal water incubated at room temperature for 16 weeks. Degradation was determined to be chemically, and not microbiologically mediated, with a half-life of 26 days.

The effects of pH on the pseudo-first order and second order hydrolytic degradation rates were calculated for a seven-week period at 30°C. Rate constants were independent of pH at $pH \leq 7$.

Adsorption and desorption rates on irrigation canal sediments were determined. Partition coefficients obtained from a review of the literature were related to characteristics of ethion and sediment.

11:00 am ENV-126 A Comparison of Copper Concentrations in Blue Crabs Collected from Polluted and Non-polluted Estuarine Environments. MICHAEL D. SULLIVAN AND JOHN H. TREFRY, Department of Oceanography & Ocean Engineering, Florida Institute of Technology, Melbourne, Florida 32901. Copper concentrations in claw and gonad tissue from the blue crab, Callinectes sapidus, were compared for a copper stressed and non-stressed area of the Indian River Estuary, Florida. The Eau Gallie Harbor is one area where high concentrations of copper in the water, sediment and barnacles are found relative to many areas in the open Indian River System. Our study revealed higher, but not statistically different, Cu concentrations in claw tissue from Eau Gallie Harbor crabs (15 ± 9 μg/g, dry wt.) than from open river organisms (9 ± 4 μg/g). Due to the transience of the crab, this is not wholly unexpected; however, the Cu content of gonad tissue from harbor crabs (25 ± 10 μg/g) was significantly higher than in open river organisms (11 ± 7 μg/g). Such observations raise concern for bioaccumulation of potentially toxic metals by blue crabs and other organisms who frequent restricted coastal embayments.

11:15 am ENV-127 An Analysis of Increased Ozone Concentrations over Florida. DALE ASPY, Dade Co. Dept. Env. Res. Man.; H. MOORE, Florida International U., Miami, FL 33199; P. HAAGENSON, NCAR, Boulder, CO 80307. Ozone readings above the National Ambient Air Quality Standard of 120 ppb were recorded in Miami during October, 1978 and August, 1980. Four possible causes were considered: (1) sea breeze effect, (2) offshore sources, (3) long range transport, (4) stratospheric injection. It was found that similar high readings occurred over the state on the same days. Air parcel trajectories were computed for these episodes. The August, 1980 episode was due to advection of lower tropospheric air from the Southeastern U.S. The October, 1978 episode was due to the injection of stratospheric air into the region over The Great Lakes followed by subsidence and transport into Florida. These parcels apparently contained ozone and ozone percursors. The impact of these findings on current ozone control strategies will be discussed.

FRIDAY 11:30 am Sage Hall, Room 102
BUSINESS MEETING: Environmental Chemistry Section
RICHARD H. PIERCE, Mote Marine Laboratory, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 3:45 pm Sage Hall, Room 205
SESSION B
RICHARD H. PIERCE, Mote Marine Laboratory, presiding

3:45 pm ENV-128 Water Quality Characteristics of the Caloosahatchee River, Florida. THOMAS H. MILLER AND ANTHONY C. FEDERICO, South Florida Water Management District, Box V, West Palm Bch, 33402. This report concludes a three year study (1978-80) to determine the water quality in the major river basins and the relative impact of Lake Okeechobee and the tributaries on the river. Discharge at the three major water control structures was unusually high during the dry season. The river consisted of highly mineralized water, high color, and daytime dissolved oxygen of 6.3 mg/L. The river also was generally well mixed except for dissoved oxygen which was vertically stratified during the summer. Phosphorus showed a well defined seasonal and discharge related pattern at S77. Phosphorus increased in the east basin and decreased in the west basin due primarily to tributary influence. Total nitrogen and ammonia levels decreased along the river while nitrate increased. Lake Okeechobee provided most of the water (55%), nitrogen (62%), and chloride (42%). Tributaries in the east basin contributed the most phosphorus (43%) while the west basin tributaries contributed the least of both phosphorus and nitrogen.

4:15 pm ENV-129 Factors Affecting Measured Phytoplankton Production in the Upper St. Johns River. THOMAS V. BELANGER, Florida Institute of Technology, Melbourne, FL 32901. Phytoplankton and community productivity studies were conducted for 15 months in 1980 and 1981 in the upper St. Johns River. Results indicate that phytoplankton production is low and usually a small percentage of the total production. It is suggested that a photochemical ferrous-ferric iron catalytic cycle contributes to the low measured productivity in the system. To support this, a stepwise multiple regression equation with solar radiation, color and iron as predictors of gross production resulted in a statistically significant relationship ($r = .91$; $p < .01$). Nutrient bioassay studies were inconclusive and indicate the system is often N and P co-limited.

4:30 pm ENV-130 The Relationship of Tidal Inundation Frequency and Pore Water Chemistry to Mangrove Community Structure. P. CARLSON, L. YARBRO, C. ZIMMERMANN, AND J. MONTGOMERY. Pore water chemistry and mangrove community structure were studied on an overwash mangrove island in the Indian River. Rhizophora mangle was present throughout, while Avicennia was limited to the upper 10 cm of elevation on the island. Rhizophora-dominated areas around the perimeter of the island were flooded regularly by the tides, while the areas dominated by Avicennia were flooded frequently only during the fall and late spring. Pore water constituents fell into two groups: those which were affected by mangrove transpiration (chloride and sulfate); and those which were related to tidal inundation frequency (iron, phosphate, ammonia, and sulfide). Most pore water constituents showed marked differences between areas dominated by Rhizophora and areas dominated by Avicennia.

4:45 pm ENV-131 Sediment-water exchange of nutrients in the Indian River lagoon in Florida. L.A. YARBRO, P.R. CARLSON, C.F. ZIMMERMANN AND J.R. MONTGOMERY. Fluxes of nutrients across the sediment-water interface of shallow subtidal seagrass beds and sandy bottom areas of the Indian River lagoon were measured in situ using clear acrylic domes. Concentrations of ammonium (NH_4) and filterable reactive phosphorus (FRP) declined or remained static during daylight hours when oxygen concentrations were increasing, but increased during the night when chamber oxygen concentrations declined. Silicate concentrations generally increased throughout the incubations, but night flux rates were greater than day flux rates. Fluxes of NH_4, FRP and silicate peaked in the fall and were generally greater from the silty seagrass sediments than from adjacent sand bottom areas. Nitrate concentrations and fluxes were virtually undetectable. Primary producers at the sediment-water interface appeared to influence the flux of nutrients to the water column during the day.

5:00 pm ENV-132 Coprostanol Distribution in Sarasota Bay, ROBERT C. BROWN and RICHARD H. PIERCE, Mote Marine Laboratory, Inc., 1600 City Island Park, Sarasota, Florida 33577. Coprostanol (5B cholestan 3B ol), a fecal sterol, is being used as an innovative technique to study the distribution of sewage discharge into Sarasota Bay. Coprostanol concentrations for 23 sediment samples range from <10ppb to >2,000ppb with the highest concentrations detected within the sewage outfall area. The concentrations decrease rapidly with distance from the outfall to below the detection (10ppb) limit. Elevated concentrations are also detected within tributaries of Sarasota Bay and known sediment depositional areas. These values may be due to stormwater runoff, boat moorings or drainage of septic fields. Correlation of these data with other water quality parameters is continuing. This project is funded jointly by the City and County of Sarasota and the U.S. EPA.

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FLORIDA COMMITTEE ON RARE AND ENDANGERED PLANTS AND ANIMALS

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

SATURDAY 9:00 am Sage Hall, Room 213
JAMES N. LAYNE, Archbold Biological Station, presiding

9:00 am REB-133 Impact of Habitat Modification on Rare Bryophytes. HARVEY A. MILLER, University of Central Florida, Orlando, FL 32816. Peninsular Florida has the greatest number of tropical bryophyte species of any state. The northern limit of range for many of these is approximately along the climatic tension zone extending across Florida just north of Orlando. Hardwood hammocks in the everglades have been the only known North American stations for several species of epiphyllous and epiphytic leafy liverworts as well as a few mosses. Absolute known limits for many species of both groups occur in the Black Hammock on the south and east sides of Lake Jessup in Seminole County. Since these were collected in the early part of this century and some have not been again found, timbering, agricultural clearing and drainage would appear to have eliminated these populations. In addition to deep hammocks, large limestone sinks provide both a moderated climate and edaphic conditions favorable for tropical species. Preservation of hammocks and natural sink vegetation will assure that other rare species of phytogeographic significance will not be eliminated.

9:15 am REB-134 Migrations of Western Atlantic Loggerhead Turtles: Evidence from Remote Recoveries of Turtles Tagged on the Florida Atlantic Coast. LLEWELLYN M. EHRHART, University of Central Florida, P.O. Box 25000, Orlando, FL 32816. Of 3509 loggerhead turtles (Caretta caretta) tagged in Brevard, Volusia, Nassau and Duval Counties since 1973, 17 have been recovered at distances greater than 100 km. Of these, 41% are from the islands of Little Bahama Bank and nearby Eleuthera; and 30% are from the Gulf of Mexico (ranging as far west as Breton Sound, off Louisiana). Virtually all of the rest represent loggerheads that wandered north along the Southeast coast in late summer and early fall. These preliminary results suggest a duality in the migratory routes and destinations of loggerheads nesting on the beaches of east Florida. The pattern of recoveries suggests that those migrating to the Gulf may simply follow the shallow waters of the Continental Shelf 1400 km or more. Although their route is much shorter (ca. 350 km), those migrating to Little Bahama Bank are more remarkable navigators in that they depart from the Continental Shelf and traverse at least 70 km of open ocean (400-500 fathoms).

9:30 am REB-135 Wood Stork Productivity in North and Central Florida. JAMES A. RODGERS JR., Florida Game & Fresh Water Fish Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601. First year results of a five year program to monitor the reproductive success of wood storks are presented for eight north and central Florida colonies. Average clutch size was relatively consistent among colonies. However, the fledging rate varied considerably and ranged from 0 - 2.3 fledglings/nest. The two north Florida colonies exhibited the highest breeding success. Causes of reproductive failure are discussed.

9:45 am REB-136 Plumage and Molt of Sandhill Cranes. STEPHEN A. NESBITT, Florida Game & Fresh Water Fish Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601. During a study of sandhill cranes (Grus canadensis) in Alachua County Florida, we have banded, color marked, and dyed the inside lining of the wings of 300 cranes. At the time of capture notes were made on plumage and soft part characteristics of each individual. About 10% of the birds trapped each year are recaptures from previous years. Each recapture is examined to gain knowledge of molt patterns, timing of molt, and changes in soft characteristics as juvenile birds mature. Wing molt patterns in cranes, both migratory (G. c. tabida) and non-migratory (G. c. protensis), are protracted over a 3-4 year period and can serve as a tool for aging cranes. We have also noticed a high percentage of cranes with white feathers, variously scattered over the body.

10:00 am REB-137 Historical and Present Occurrence of the Red-cockaded Woodpecker in Southern Florida. WILLIAM B. ROBERTSON, JR., AND GARY A. PATTERSON, South Florida Research Center, Everglades National Park, Homestead, FL 33030 and 3775 7th Ave., NW, Naples, FL 33999. Picoides borealis, originally found south to the limit of pine forest on the mainland, has disappeared from much of its former range in southern Florida. Lumbering of old-growth pine reduced and fragmented the population but colonies persisted in many areas. Since about 1950, levelling of pine forest for land development has tended to eliminate these relict groups. Relatively secure populations of 15 to 40 colonies exist on 4 widely separated tracts of public land in the southern half of the peninsula. Elsewhere, the species is gone from southeastern Florida and the scattered remnant colonies in southwestern Florida will soon be gone unless sites are protected and managed. Re-introductions and possibly transfer of birds between isolated populations may be needed to assure long-term survival of the species in southern Florida.

10:15 am BREAK

10:30 am REB-138 Status and habitat of Peromyscus polionotus on Merritt Island. I. JACK STOUT, Department of Biological Sciences, University of Central Florida, Box 25000, Orlando, FL 32816. Distribution and abundance of the beach mouse, Peromyscus polionotus, will be discussed with respect to its habitats on Merritt Island, Brevard County. Continuous trap-recapture studies covered 37 months, 1976-1979, at two sites selected to represent optimal and marginal habitats. Known numbers of mice at the coastal site (optimal habitat) were remarkably stable for the first 24 months of study; unusually high densities were observed over the last 14 months of study. Implication of the unusual abundance will be discussed relative to population regulation. Minimum numbers of mice at the inland site (marginal habitat) were consistantly lower and more variable when compared to the coastal population. However, marginal habitats were generally occupied throughout the Canaveral Peninsula. Timing of annual population increases on the inland study site suggested that immigration may have been significant. The future of these populations will be discussed with respect to conservation and management.

10:45 am REB-139 Black Bear Research in Florida: An Update. DAVID S. MAEHR, Florida Game & Fresh Water Fish Commission, Wildlife Research Laboratory, 4005 South Main Street, Gainesville, FL 32601. Recent research on black bears (Ursus americanus) conducted by the Florida Game & Fresh Water Fish Commission is summarized and discussed. An updated distribution map has been completed via consultation with local authorities and on-site inspections. A food habits study, using 71 stomachs collected statewide is in final stages of analysis. A survey of beekeepers revealed that 29% of the respondents had experienced bear depredation. Out of 67 counties, 41 were indicated as having a depredation problem. Full-time beekeepers experienced the largest amount of black bear depredation on apiaries. Annual losses were established at over $100,000. South Florida experienced no peak in the annual rate of depredation, while for the rest of the state, depredations peaked in May. Electric fences were the preferred method of protection. Future projects are discussed.

11:00 am REB-140 An Investigation of Manatee Acoustics. CATHY STEEL AND JOHN G. MORRIS, Florida Institute of Technology, Melbourne, FL 32901. Vocal and non-vocal sounds of the West Indian manatee, Trichechus manatus were analyzed. Manatee sounds were recorded in both captive and non-captive environments using a USRD hydrophone and four-channel tape recorder. Behavioral observations were made simultaneously. Subsequent analyzation included digitizing the signals to obtain time and frequency domain plots. Currently, speech analysis is also being accomplished using three-dimensional plots of frequency versus time versus energy output.

11:15 am REB-141 Protecting Endangered Species at the Local Governmental Level. JEFFREY L. LINCER, Director, Office of Environmental Management, Sarasota County, P.O. Box 8, Sarasota, FL 33578. At this point in history, Sarasota County provides habitat suitable for 5 mammals, 14 birds, 1 amphibian, 5 reptiles, and 4 plants, considered endangered or threatened at the state and/or federal level. Protective habitat and people management guidelines were developed for these species and provide a basis for a legally-required environmental review of applications for changes in land use, such as those associated with the rezoning and special exception processes. By working with the landowners and developers during the early phases of the site planning process, much can be done to minimize and mitigate the impact of habitat development on endangered species.

SATURDAY 11:30 am Sage Hall, Room 213
BUSINESS MEETING: Florida Committee on Rare and Endangered Plants and Animals
LLEWELLYN M. EHRHART, University of Central Florida, presiding

GEOLOGY AND HYDROLOGY

FRIDAY 8:15 am Sage Hall, Room 213
SESSION A
DAVID P. SPANGLER, University of Florida, presiding

8:15 am GHY-142 MANAGEMENT OF SALINE WATER INTRUSION IN THE SOUTH FLORIDA WATER MANAGEMENT DISTRICT. Lauran L. Howard, John T. Massey-Norton, and Patrick J. Gleason, South Florida Water Management District, P. O. Box V, West Palm Beach, FL 33402. The South Florida Water Management District attempts to control saline water encroachment on a short-term basis by operation of a system of salinity control barrier structures on canals and on a long-term basis by management of withdrawals from groundwater and surface water. At the present time 46 utilities are required to have SWIMM (Saline Water Intrusion Monitoring and Management) programs to define and track the location of the saline water interface. This paper documents historical saline water encroachment at five major utilities along the southeastern coast of Florida.

8:30 am GHY-143 Daily Rainfall Distribution in Everglades Agricultural Area. S. F. SHIH, University of Florida, Agricultural Research and Education Center, Belle Glade, Florida 33430. Considerable water is used in south Florida for agricultural production. Unfortunately, water users face a critical problem, i.e., the uneven rainfall distribution in Florida. For instance, the yearly rainfall cycle in south Florida consists of a May through October warm-rainy season, during which about 75 percent of the total rainfall occurs, and a six-month relatively dry winter season. In this study, the daily rainfall data gathered by the Agricultural Research and Education Center, Belle Glade, during the period 1926-79 were analyzed. The results showed that the daily rainfall (>5 mm) were about 10% during the period of dry season, about 17% during the months of May and October and were about 30% during the months of June through September. The distribution pattern in the last 20 years (1960-79) showed a significant difference from that of the long term 54 year period.

8:45 am GHY-144 Ecosystem Models Applied to Hydrogeological Problems. MANUEL T. MENDEZ,DANIEL P.SPANGLER and KATHERINE C. EWEL,Departments of Geology and Forest Resources & Conservation,University of Florida,Gainesville,FL 32611.When trying to evaluate regional recharge of an aquifer using meteorological data,frequently either evapotranspiration records are not available or they are not adequately estimated. As a result,effective infiltration reaching the aquifer systems can be misinterpreted.Using hydrogeological information from recent investigations of Lake Wauberg,Alachua County,Florida,by researchers of the University of Florida,ecological simulation systems have been used to evaluate hydrogeological parameters.Quantitative validation can then be made with the physical values measured.

9:00 am GHY-145 An Analysis of Groundwater Quality in North Central Peninsular Florida. MARK SILVERMAN AND DANIEL P. SPANGLER, Dept. of Geology, University of Florida, Gainesville, FL 32611. A cooperative effort is presently being made by investigators at the University of Florida, the USGS and the Groundwater Section of the Florida DER to establish a groundwater quality monitoring network for the State of Florida. The design of this network is to be based on such factors as geologic and hydrologic setting, background hydrogeochemical data and the sensitivity demonstrated by the aquifer to alteration and contamination by environmental influences. A study area within north central peninsular Florida was selected to focus consideration on factors involved in a regional assessment, including the following: construction of hydrogeochemical contour maps, delineation of hydrogeochemical facies for each physiographic province present, assessment of environmental impact on groundwater quality within the flow regime, and seasonal and annual variation observed in the hydrogeochemical values. Based on a consideration of the foregoing, suggestions will be made for a network design for future monitoring efforts.

9:15 am GHY-146 A Mineralogical Model of the Floridan Aquifer. JONATHAN I. BLOOM, Univ. of Florida, Dept. of Geol., 1112 GPA, Gainesville, FL 32601. The distribution of geologic and hydrologic parameters in wells penetrating the Floridan Aquifer along portions of the western coast of peninsular Florida are related to the occurrence of dolomite. Trace element analyses of the cores indicate correlations between strontium content and the particular carbonate phases (i.e. strontium content is approximately half as much in dolomites as it is in calcites). Chloride, sulfate, and conductivity values are used along with temperature distribution to indicate the position of the salt-water/fresh-water interface. Dolomite is concentrated in the lower portions of the cores and can be found at shallower depths nearer to the coast. Correlations between the dolomite-calcite boundaries and the position of the salt-water/fresh-water interface suggest that this interface is of major importance in the dolomitization process.

9:30 am BREAK

9:45 am GHY-147 The Hydrogeologic and Geomorphic Influence of a Previously Unmapped Clay Bed in North-Central Florida, R. E. COPELAND, Suwannee River Water Management District, Rt. 3, Box 64, Live Oak, FL 32060. Auguring revealed the existence of a previously unmapped clay bed in north-central Florida. The clay bed seldom exceeds a thickness of 2 m. It is covered by a veneer of porous sand, and it overlies the carbonate beds of the Floridan Aquifer. The clay bed acts as an upper semi-confining unit to the Floridan Aquifer and the base of a seldom used surficial aquifer. Most of the study area is located in a karst plain. In portions of the study where the clay is present, the bed has slowed down the vertical migration of acidic ground water from the overlying sands. This has resulted in a reduced number of karst features. The vadose zone seldom exceeds a thickness of 1 m. The resulting shallow water table has restricted cultural development. However, in regions of the study area where the clay bed does not exist, the vadose zone is up to 15 m. thick. Cultural features in these regions are significantly more developed than in portions of the study area where the bed does exist.

10:00 am GHY-148 Determining Formation Water Quality from Electric Logs Run in Small Diameter, Mud Filled Test Holes. THOMAS KWADER, Northwest Florida Water Management District, Rt. 1, Box 3100, Havana, FL 32333. Deep penetrating and focused electric logs have been successfully used in shallow test holes to determine lithology, porosity, permeability and formation water quality. These parameters can be determined in small diameter test wells without actually completing or pumping the well. Although electric log interpretations are based upon the formations being of a granular nature, accurate water quality, lithologic, porosity and permeability measurements can be made in carbonates when used in conjunction with other types of logs. Once the water quality of the various aquifers are evaluated, flowmeter logs can aid in determining which zones to develop in order to produce the maximum quality at the desired yield. Permeabilities can be inferred in freshwater zones since the electrical resistance is largely a function of surface conductance of the grain contacts which is directly related to the grain size and interconnectedness of the pore spaces.

10:15 am GHY-149 A Seismic Refraction Profile of the North Florida Crust. MARCUS L. JARRETT, W. BRUCE LAFRENZ, AND DOUGLAS L. SMITH, Department of Geology, University of Florida, Gainesville, FL 32611. A seismic refraction profile trending northwest-southeast and extending approximately 50 km from Newberry, Alachua County, Florida, to Lowell, Marion County, Florida, was conducted with quarry blasts as energy sources and portable earthquake seismographs as detectors. The travel time data yielded a simple two layer model with an upper unit velocity of 3.71 ± 0.25 km/sec and a lower unit velocity of 6.15 ± 0.15 km/sec. The upper layer is interpreted to represent the Coastal Plain and underlying Paleozoic sedimentary rock sequence while the lower layer is considered representative of crystalline basement such as the granitic Avalon Complex. A depth of 3.28 ± 0.2 km is computed for the interface, closely approximating previously published estimates based on gravity data.

10:30 am GHY-150 Geologic Modeling in the Lake Wauberg Vicinity Utilizing Seismic Refraction Techniques. JACK M. WEINER, DOUGLAS L. SMITH, and DANIEL P. SPANGLER, Department of Geology, University of Florida, Gainesville, FL 32611. A high resolution shallow seismic refraction survey was conducted in the Lake Wauberg vicinity of Alachua County, Florida, to discern the structural relationship of the Ocala limestone to overlying surficial ponds. Thirty-five reversed refraction profiles completed with a hammer-activated Nimbus seismograph yielded velocity ranges of 1,140-1,250 ft/sec for the surficial sands, 2,500-5,800 ft/sec for Hawthorne clays, and 6,200-11,000 ft/sec for the Ocala Group limestone. Seismic discontinuities were consistent with known geologic interfaces. Interpretation of the data by computer graphics, velocity analysis, and correlation with six boreholes in the study area suggest depths to the limestone surface ranging from 17 ft at the southern edge of Paynes Prairie to 112 ft along a structural lineation which may control the orientation of the surficial ponds. This investigation demonstrates the applicability of the shallow refraction technique for mapping subsurface karst features.

10:45 am GHY-151 Evidence for Shallow Subsurface Faults in Northeast Florida. T. M. SCOTT, Florida Bureau of Geology, 903 W. Tennessee St., Tallahassee, Fla. 32304. During recent subsurface investigations in northeastern Florida evidence indicating the existence of several faults was encountered. This information suggests that the St. Johns River does follow a fault influenced course from Lake George to near Palatka as previously suggested by Pirkle (1971).

All the faults offset the top of the Eocene Ocala Group. One fault appears to have offset the Ocala Group, the Hawthorn Formation and the post-Hawthorn shell beds indicating a possible Pliocene or younger age for that fault.

FRIDAY 11:00 am Sage Hall, Room 213
BUSINESS MEETING: Geology and Hydrology Section
SHERWOOD W. WISE, Florida State University, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 2:45 pm Sage Hall, Room 213
SESSION B
SHERWOOD W. WISE, Florida State University, presiding

2:45 pm GHY-152 Holocene Lagoonal Sedimentation, Vieques, Puerto Rico. GARY M. D'ALUISIO-GUERRIERI AND RICHARD A. DAVIS, JR., Department of Geology, University of South Florida, Tampa, FL 33620. Four lagoons along the southern shore of Vieques exhibit recent changes in morphology and show varying degrees of interaction with open marine waters. Cores taken perpendicular to surface deposition environments reveal a stratigraphy of easily definable facies displaying a sequential development of infilling of these lagoons during the Holocene sea level rise. Sediments derived from terrigeneous sources gradually give way to marine carbonate sediments in the open lagoon. Terrigeneous sediments are now accumulating landward of an extensive mangrove fringe. This mangrove fringe is prograding into the lagoon and is presently losing its trailing edge to increased sedimentation on the alluvial flats behind. Marine carbonate sediments are dominated by muddy molluscan sand and Halimeda sand facies.

3:00 pm GHY-153 Petrology and Paleoenvironmental Interpretation of the Smackover Fm., Apalachicola Embayment. FELIPE A. PONTIGO AND WILLIAM PARKER, Bureau of Geol., DNR, Tallahassee, FL 32306. The Upper Jurassic Smackover Formation forms a subsurface belt of sediment, extending along the northern Gulf Coast from east Texas to northwest Florida. A lithostratigraphic study of the formation in the Apalachicola embayment area indicates deposition during a transgressive-regressive cycle. A lower transgressive unit is dominated by carbonate sediments surrounding a central "tongue" of clastics, while an upper regressive unit is predominantly clastic. The carbonates in both units range from mudstones to peloidal packstones and contain a sparse foram-arthropod-molluscan fauna. Diagenesis has resulted in dolomitization, extensive neomorphic recrystallization and secondary porosity evolution. The clastics are gray sands, silts and muds, often found as thinly bedded rhythmites containing fragments of lignitic material. The sediments are inferred to represent deposition in restricted, shallow, near-shore marine and tidal mudflat environments.

3:15 pm GHY-154 What is the Apalachicola Embayment? WALTER SCHMIDT, Florida Bureau of Geology, Tallahassee, FL 32304. Differing opinions on the nature and origin of the Apalachicola Embayment have been expressed by numerous geologists. Some have favored the hypothesis that a graben is responsible for the feature. Others have preferred a downfaulted embayment, a syncline, a solution valley, a submarine valley, or a current-swept strait. The feature has also been referred to by nearly a dozen different names. Trends from structural and isopach maps show an apparent pattern when these are successively plotted from oldest to youngest. The axis of the embayment shifts eastward at the end of the Cretaceous, then migrates westward through the Tertiary. From the data it can be concluded that an embayment existed in Mesozoic times and probably originated structurally. By the close of the Mesozoic Era the embayment was filled and no longer appeared as a topographic low. The feature in the Tertiary seems to have been formed due to nondeposition and subsequent infill. During the Holocene the embayment has been completely filled once again and is occupied now by the Apalachicola River and its delta.

3:30 pm GHY-155 An Interpretation of Environmental Conditions Along Florida's East Coast During the Middle Miocene and Early Pliocene. RONALD W. HOENSTINE AND SHERWOOD WISE, Florida Bureau of Geology and Florida State University, Tallahassee, 32304. Well preserved assemblages of diatoms and silicoflagellates of Middle Miocene and Early Pliocene age were observed in cores and cuttings from Cumberland Island, Georgia and Florida's east coast. The co-occurrence of upwelling and temperate to warm water species is significant and suggests, as possible explanations, the mechanism of upwelling or the existence and proximity of an offshore cool water current during the Middle Miocene. Supporting data includes the presence of well preserved siliceous microfossils, benthic foraminifera, and appreciable concentrations of phosphorite. In contrast to the large number of cool water species present in the Middle Miocene sediments, this group was conspicuously absent in the diatomaceous Pliocene sediments.

3:45 pm BREAK

4:00 pm GHY-156 Paleoecologic Significance of Coral-Boring Bivalves from the Ocala Group of Peninsular Florida. DEBRA K. KRUMM AND DOUGLAS S. JONES, Department of Geology, University of Florida, Gainesville, FL 32611. A paleontological survey of quarries within the Upper Eocene Ocala Group of northern peninsular Florida has revealed numerous occurrences of borings of the mytilid bivalve Lithophaga sp., previously unreported from this unit. Imprinted on the external surface of the filled borings are the septal patterns of scleractinian corals. Since the Ocala Group is essentially devoid of fossilized coral, presumably as a result of dissolution, these coral-boring bivalves record the existence and identity of some of the Late Eocene coral fauna. Observations on the densities and orientation of the borings suggest to us a patch reef paleoenvironmental setting. In addition, the borings may have biostratigraphic value within the Upper Eocene.

4:15 pm GHY-157 Ontogeny and Phylogeny of Eocene Oligopygoids from the Ocala Limestone of Peninsular Florida. MICHAEL L. MCKINNEY AND DOUGLAS S. JONES, Department of Geology, University of Florida, Gainesville, FL 32611. The Upper Eocene Ocala Limestone in peninsular Florida is characterized by 3 species of the irregular echinoid genus Oligopygus. The 3 species, O. phelani, O. haldemani, and O. wetherbyi, form an evolutionary lineage in which the stratigraphic range of each species roughly corresponds with the Inglis, Williston, and Crystal River biozones, respectively. Computer-assisted biometric analyses of 1113 individuals were carried out on all 3 species from throughout their stratigraphic ranges, using specimens representing all ontogenetic stages. The data indicate that morphologic development during ontogeny was extremely uniform (i.e. non-allometric) in all 3 species. While the lineage exhibits an overall phylogenetic trend toward size increase, diagnostic species characters show morphological stasis throughout each species lifespan. This stasis plus the absence of intermediate forms suggest either rapid speciation events (punctuated equilibrium) or environmentally-triggered species migrations.

4:30 pm GHY-158 The Clay Mineralogy of the North Florida Everglades. ROBERT K. SAWYER AND GEORGE M. GRIFFIN, Geology Department, University of Florida, 32611. Approximately 700 cores were taken in the fall of 1981 in the North Florida Everglades as a result of recent interest by the Department of Energy in the fuel-grade potential of Florida peats. Clay mineral suites were identified in all peat types and the underlying limestone basement rock. The results may point to the source of the clay minerals and help determine the environment of deposition for the limestone and peats. Emphasis was placed on the association between clay specie and amount, and the fuel-grade peat type.

4:45 pm GHY-159 Metal Zoning in Fissure Veins, Topia, Durango, Mexico. ROBERT R. LOUCKS, Geology Dept., Florida State Univ., Tallahassee, FL 32306. Distribution patterns of Ag, Au, Pb, and Zn were determined in five untectonized, crustification-banded, epithermal fissure veins in Tertiary andesites, employing assay data from 6000 localities, a new graphical method of trend analysis, and contouring of metal ratio and concentration data on longitudinal vein sections. Results show that along each vein, rich ore is confined to a sub-horizontal, sinusoidally contorted ore "ribbon" of small (25-100 m) width, a vertical amplitude of 150-250 m, and a strike length of several km. Sinusoidal inflections of metal ratio contours coincide with variations in fissure aperture (permeability) and closely resemble sinusoidal inflections of isotherms in experimental long Hele-Shaw cells with multiple fluid convection cells. The chemical contours permit reconstruction of general features of fluid circulation patterns in the fissures and provide guides to specific locations of undeveloped ore, as well as an improved basis for estimating ore reserves and broad-scale guides to district exploration.

5:00 pm GHY-160 **Evaluation of X-ray Data for Phosphate Minerals in Terms of Computerized Phase Identification.** FRANK N. BLANCHARD, Department of Geology, University of Florida, Gainesville 32611. Computer search and match programs for identification of minerals by X-ray diffraction methods fail to identify correctly a substantial number of phosphate minerals. These failures may be attributed in part to a lack of high quality X-ray diffraction standards in the data base. Evaluation of X-ray diffraction standards for the phosphate minerals has been carried out in order to identify those species for which better data are needed. Part of the evaluation consists of calculation of a figure of merit for each pattern. Computer software and automated X-ray diffractometers soon will be in routine use for automatic phase identification. These systems will be powerful tools to aid in solving problems which require phase identification, but they will fail where the data base is inferior. This preliminary evaluation of patterns for phosphates will be followed by preparation of new standards for some of those phases which are found to be poorly represented in the X-ray powder diffraction file.

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

MEDICAL SCIENCES

(NOTE: see p. 56 for program)

PHYSICAL, ATMOSPHERIC, OCEANOGRAPHIC, AND SPACE SCIENCES

FRIDAY 8:15 am Sage Hall, Room 102
SESSION A: Oceanography and Meteorology
DEAN R. NORRIS, Florida Institute of Technology, presiding

8:15 am PAO-161 The Effect of Synthetic Seagrass on Sedimentation and Community Structure. BRUCE RUMISH, Department of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, FL 32901. As the problem of coastal erosion increases, new techniques to enhance coastline stability, such as synthetic seagrass, are being developed. Synthetic seagrass promotes sedimentation and increases bottom stability by reducing current velocity. This study was conducted in the Indian River lagoon, Florida. Changes in deposition rates and grain size distribution were analyzed, as well as changes in the infaunal and epiphytic communities. It appears that the emplacement of synthetic seagrass caused increases in deposition, especially fine grained sediments and increases in the fauna, primarily due to the addition of epiphytic organisms.

8:30 am PAO-162 Effects of Periodic Upwelling on Phytoplankton Biomass and Productivity on the East Florida Continental Shelf. JOHN J. HEFFERNAN, R.A.GIBSON, C.F. ZIMMERMANN, Harbor Branch Foundation, Rt. 1, Box 196, Ft. Pierce, Fla. 33450. Concurrent measurements of chlorophyll, primary production, temperature, salinity, and nutrients were made along a three station, 28 Km transect off Ft. Pierce, Fla. from March to December, 1981. Biological succession initiated by the upwelling occurred in May when a deep-water mass moved onto the shelf. During this time productivity values reached a maximum of 120 mgC.m^{-2} hr^{-1}. Peak rates during non-upwelling periods never exceeded 18 mgC.m^{-2}. hr^{-1}. Chlorophyll values were 10-100x greater in the cold-core eddy. Nutrient concentrations were low and often undectable during the non-upwelling period. Nitrate-nitrite concentrations were generally less than 1 uM except during the upwelling when values as high as 10 uM on the inner shelf and 18 uM on the middle shelf were observed. The upwelling phenomena lasted only 4 weeks.

8:45 am PAO-163 Environmental Monitoring Associated with the Port Everglades Harbor Deepening Project of 1980. RUSSELL E. PUTT, DAVID A. GETTLESON, M. JOHN THOMPSON, AND RICHARD M. HAMMER, Continental Shelf Associates, Inc., P.O. Box 3609, Tequesta, FL, 33458. Extensive ecological monitoring of hardground communities adjacent to Port Everglades, Florida was conducted over a one year period; before, during, and after major entrance channel dredging operations. Currents oscillated considerably between north and south but showed a net northward transport. Water temperatures remained within seasonally normal limits (20 to 29°C). A mid-summer decrease in water temperatures was followed by a marked increase in filamentous algal growth. A mean annual sedimentation rate of approximately 75.7 mg/cm^2/day was determined for the hardground areas. No detectable increase in sedimentation or damage to the biological assemblages were associated with the dredging operations. Growth of the hard coral populations appeared to be severely limited by the area's environmental characteristics.

9:00 am PAO-164 Partitioning of Manganese and Iron in the Carbonate-Rich Sediments of the West Florida Shelf. SIMONE METZ AND JOHN H. TREFRY. Department of Oceanography and Ocean Engineering, Florida Institute of Technology, Melbourne, Florida 32901. Sediment samples collected from the West Florida Shelf were analyzed to determine Fe and Mn partitioning in carbonate and non-carbonate fractions as a function of grain size. The fractions were defined by selective leaching of the sediments with a pH 5 buffer technique and total dissolution of the resultant residue. These samples, which average 85% carbonate (range 35-99%), have <10% of the total Fe (660 to 10,700 ppm total Fe) in the carbonate phase. Thus, concentrations as high as 13% Fe have been measured in the non-carbonate phase. For Mn, however, 80% of the total 10 to 130 ppm Mn is in the carbonate phase. A conceptual model showing distribution patterns for both metals has been developed as a function of grain size, metal concentrations in the carbonate and non-carbonate phases, and sample location offshore.

9:15 am PAO-165 Prediction of Stress in Tidal Currents. RONNAL P. REICHARD, Oceanography and Ocean Engineering Dept., Florida Institute of Technology, Melbourne, Fl. 32901. A method for the prediction of stress in tidal currents has been developed. This method, called the Extended Profile method, is based on an eddy viscosity model and is a dynamic version of the steady state Log Profile method. The Extended Profile method involves fitting a modified eddy viscosity model to current profile data using a least squares technique to obtain stress as a function of depth and time. The method has several advantages over the Log Profile method for use in tidal situations. Standard current profile data is used to make the stress predictions, which are continuous in depth and time, and no steady state assumption is involved. Its principal disadvantage is that eddy viscosity coefficients must be determined. The Extended Profile method has been applied to a current velocity data set collected in a tidal channel. The resulting stress predictions are compared with stress measurements and with bottom stress predictions using the Log Profile method and the Quadratic Stress Law.

9:30 am PAO-166 The Sensitivity of Aircraft Measured Meteorological Parameters to Small Changes in the Raw Data Inputs. FRANCIS J. MERCERET, NOAA Research Facilities Center, P.O. Box 520197, Miami, FL 33152. Research Facilities Center (NOAA) WP3D "hurricane hunter" aircraft make 16 direct measurements which are converted to 29 derived meteorological and navigational variables. A theoretical evaluation of the 464 partial derivatives of the derived outputs with respect to the given inputs was done and was confirmed by numerical simulation. The results presented provide information about which outputs are susceptible to significant contamination by noise or small calibration errors and which inputs are most critical to high accuracy data. Quantitative examples are given.

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 2:45 pm Sage Hall, Room 102
SESSION B: Physical Sciences
STEPHEN L. MINTZ, Florida International University, presiding

2:45 pm PAO-167 Quantitative Analysis of Schlieren Photography. DAVID SOLLBERGER, TIM CORNNELL, VINICIO FERNANDEZ, KIM LARSON, MARK BARTLETT, CHRIS CORNNELL, AND CHRIS COLLINS, Palm Beach Junior College Science Club, South Campus, 500 N.W. 20th St., Boca Raton, Fl. 33431. A determinative study into the usage of schlieren photography on subsonic fluids. Photographs were recorded of 30, 40 and 50° two-dimensional wedges at three speeds in a hydro-tunnel. The two-dimensional models span the hydro-tunnel to reduce surface tension effects. The compressibility effects of the water in the closed hydrotunnel system were not significant enough to register, so a secondary temperature medium was injected into the main flow upstream from the model. The secondary medium induced a refractive indicies change surrounding the models. Currently a manometric study of the models and a photoelectric analysis of the negatives are being completed. Data will be presented at the conference.

3:00 pm PAO-168 A Photometric Study of Post Main Sequence Eruptive Variable Stars. EDWIN F. STROTHER AND J. ALLYN SMITH, Florida Institute of Technology, Melbourne, Florida, 32901. While the most numerous of the non-periodic variable stars can be broadly classified as eruptive variables, the exact mechanism giving rise to the variability in brightness of many of these interesting objects remains to be determined. Their very unpredictability makes eruptive variables difficult to study, however, they are astrophysically important in that they provide useful information about the structure, properties, and evolution of stars. A photoelectric photometry program which is currently underway at the Florida Institute of Technology observatory to monitor selected post main sequence variable stars will be described and the results of this study discussed.

3:15 pm PAO-169 Intrinsic Brightness Changes in AR Lacertae. YOUNG WOON KANG, Department of Astronomy, University of Florida, Gainesville, FL 32611. AR Lacertae was observed at Yonsei University Observatory, Korea for two years, 1976 and 1977. It has been observed at both observatories, Yonsei University Observatory and Rosemary Hill Observatory, Florida as a US - Korea joint project since 1979. Entire light curves in three colors are almost completed. The depth of the primary minimum in the yellow light shows no variation in any one year but differences between year and year. This indicates a long-term variation of AR Lacertae. Nine new times of minimum light were determined.

3:30 pm BREAK

3:45 pm PAO-170 Application of X-Ray Spectroscopy in Determining Ancient Pottery Sample Origins. RODNEY A. SIMMONS, K.A. HARDY, Dept. of Physical Sciences, Florida International University, Miami, Fla, 33199; D. WALKER, U. of F., Gainesville, Fla. An X-Ray Fluorescence Spectrometer is used in combination with a computer based data acquisition system to determine the relative concentrations of various trace elements in samples of ancient pottery to determine whether two or more samples of pottery originated from the same geographic site. An X-Ray Spectrometer is used to scan a properly prepared sample of pottery using standard X-Ray Fluorescence techniques. By comparing the relative concentrations of elements between different pottery samples it may be ascertained as to whether or not the samples of pottery originated from the same geographic site.

4:00 pm PAO-171 Characteristics of the Continuous Aurora. JAMES R. SHARBER, Florida Institute of Technology, Melbourne, Fl., 32901. Polar auroras occur in a wide variety of shapes, colors, and forms. In fact, their most notable feature is this great variability. However, there is one auroral form characterized by its constancy-the continuous aurora. It is a rather uniform, relatively low-intensity nearly circular band of optical emissions surrounding the geomagnetic pole. The band is 1^{o} to 5^{o} wide depending on geomagnetic activity but is always present. It is displaced equatorward of, but usually overlaps, the oval of discrete arcs known as the auroral oval. There is compelling evidence that this aurora is essentially the footprint at auroral latitudes of the earths central plasma sheet, a reservoir of low-energy particles trapped in the geomagnetic field. This paper uses data from soft particle spectrometers aboard the Isis 2 polar orbiting satellite to describe the electrons and protons which produce the continuous aurora. The results are interpreted in terms of the plasma sheet as the source of the particle populations.

4:15 pm PAO-172 Neutrino Reactions in ^{2}H and ^{12}C and the status of Neutrino Oscillations. S.L. MINTZ, Physical Sciences Department, Florida International University, Miami, Florida 33199. A discussion of the current status of theoretical and experimental results for neutrino oscillations in ^{2}H is given. A method for calculating the cross section for the process $\nu_{\mu} + {}^{12}C \rightarrow \mu- + X$ based on total muon capture rates and the closure approximation is presented and the cross section calculated for neutrino energies from threshold to 250 MeV. The result is compared with existing experimental results and theoretical models.

4:30 pm PAO-173 Statistics of the Uniform Distribution Related to Signal Processing. PATRICK N. CARLTON, Naval Coastal Systems Center, Panama City, FL 32407. In many applications of signal processing techniques it can be assumed that background noise is uniformly, randomly distributed. A decision is usually necessary concerning whether a data sample contains a signal in addition to the background noise. Often, distributions that describe sampled data from signals are non-uniform (e.g. typical signal distributions include Gaussian, Rayleigh, etc.) In this situation, the form of the functional dependence of the statistics (mean and variance for this paper) on distribution parameters such as the number of elements in the sample and the range of the sample is of interest. This paper presents the functional form of the mean and variance of the uniform distribution and illustrates them for various sample sizes and ranges.

FRIDAY 4:45 pm Sage Hall, Room 102
BUSINESS MEETING: Physical, Atmospheric, Oceanographic, and Space Sciences Section
STEPHEN L. MINTZ, Florida International University, and DEAN R. NORRIS, Florida Institute of Technology, presiding

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

SCIENCE TEACHING

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

SATURDAY 8:15 am Sage Hall, Room 205
SESSION A
CHARLES J. MOTT, St. Petersburg Junior College, presiding

8:15 am TCH-174 Student Attitudes on Environmental Topics, 1976 - 1981. ERNEST L. RHAMSTINE, Valencia Community College, Orlando, 32811. Over four hundred students responded to an environmental attitude survey prior to any substantive discussions of environmental issues in the class. Most attitudes surveyed have remained unchanged over the past five years, however, attitudes on energy have changed significantly. The uniformity of responses to many topics was remarkable. Cross-tabulations between selected topics and demographic characteristics revealed that race, size of the sib-group and marital status were often related to the attitudes expressed. In no case did age, sex or college standing appear to influence attitudes expressed on this survey. The majority of the cross-tabulations, 276 of 296, revealed no significant differences with the demographic categories of age, sex, marital status, college standing, size of sib-group, race or number of children. The statistical evaluation was with the Chi-square statistic. All data reported in this study is pretest data collected in the academic year 1976-77 and in September, 1981.

8:30 am TCH-175 History As A Tool in the Teaching of Science. PANGRATIOS PAPACOSTA, Physics Department, Stetson University, DeLand, FL 32720. Science teaching at any level can be enriched by the inclusion of relevant events from the History of Science. The use of such a historical dimension in the teaching of science may improve much more than student interest. It can provide the foundations upon which modern science is built. It can demonstrate a sense of continuity and diversity in the growth of science. The awareness that scientific theories are never rigid in time but are constantly being modified, will encourage fresh and innovative ideas rather than a dogmatic preservation of scientific theories. Furthermore the dramas of controversy, persecution and triumphs that surround the lives and work of many scientists in history presents science more as a humanistic endeavour rather than a mechanical activity. Slowly but steadily history as a science teaching tool is appearing in some form or another in textbooks and science courses. The use and great potential of this new tool will be discussed.

SATURDAY 8:45 am Sage Hall, Room 205
BUSINESS MEETING: Science Teaching Section
CHARLES J. MOTT, St. Petersburg Junior College, presiding

SATURDAY 10:00 am Elizabeth Hall Auditorium
SPECIAL SESSION B
CHARLES J. MOTT, St. Petersburg Junior College, presiding
(NOTE: the following presentation will last 60 min)

10:00 am TCH-176 Multi Screen Panorama on the Development of Sinkholes, FRANK KUJAWA, Department of Chemistry, The University of Central Florida, Orlando, Fl., 32800. The history of the development of the spectacular Winter Park Sinkhole is pictorially illustrated using the 6-projector, multiscreen approach. Also, slides of other sinkholes are presented along with theories of sinkhole development.

SOCIAL SCIENCES

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

SATURDAY 9:30 am Carlton Student Union, Room 204/205
WALTRAUD Q. MORALES, University of Central Florida, presiding

9:30 am SOC-177 Father Custody and Middle Class Rebellion. WALTER D. TROPF, University of Central Florida, Dept of Sociology, Box 25000 Orlando, 32816. Traditional parental roles are being challenged by some segments of society. In this paper, father custody is viewed as a rejection of both cultural goals and institutional means and, according to Merton's paradigm of non-conformity, should occur largely among the middle class. Replies from a convenience sample of 101 divorced men in Central Florida indicate that middle class men are more likely to have custody than either upper class or lower class men (p. 05). An examination of ten intervening variables shows that only religion may affect this finding. This is consistent with other data on religious differences affecting behavior. The results furnish a test of Merton's theory and shed light on changes in familial roles.

9:45 am SOC-178 Integration in the Stepfamily. SHERYL BETH GAGE, UCF, Social Work Program, PO Box 25000, Orlando, FL 32816. This study reviews the literature focusing on problems in stepfamily integration. The stepfamily is not an institutionalized family form. This brings uncertainty to family life, especially when families attempt to incorporate the roles from previous families into the roles required by the new family. Because many former roles are maintained, subsystems exist that divide along former family lines. This can hamper the integration process. Financial burdens, jealousy related to former family ties and incomplete mourning all add to the problems associated with integrating the stepfamily. These problems of integration have treatment implications which are discussed.

10:00 am SOC-179 Annual Household Survey in Florida: 1981. WEN-FU P. SHIH, University of Florida, Bureau of Economic and Business Research, 221 Matherly Hall, Gainesville 32611. The Bureau of Economic and Business Research in the University of Florida is conducting survey research to generate economic and demographic data on the characteristics of Florida's households. The present paper examines the data gathered from the February through April, 1981 survey. A two-stage clustered random digit dialing (RDD) method is utilized to elicit responses from a sample of 800 households. The survey data are studied and compared among eleven geographical regions. Characteristics associated with household members, households, and household heads are analyzed along with a detailing of both intra- and interstate travel activity by Florida residents. In respect to the former, the results conclude that geographical differences exist among Floridians' age, marital status, type of family, household size, and family income distributions. The travel activity results reveal unique travel patterns for particular regions.

10:15 am SOC-180 Changes in Florida Election Patterns. Mark Stern, Political Science Department, University of Central Florida, Box 25000, Orlando, Fl. 32816. This paper examines county level socio-economic and voting data form 1948 through 1980. Specific analysis is done comparing continuities and change in the correlates of Demoncratic and Republican electoral support for the offices of President, U.S. Senator, and Governor. Internal partisan shifts in primary elections are also examined.

10:30 am SOC-181 The EPCOT Center Participating Countries: A Development Perspective. DJEHANE HOSNI, Economics Department, The University of Central Florida, Box 25000, Orlando, FL 32816. EPCOT Center is Walt Disney's greatest expansion. It's World Showcase portrays "travelling the countries of the world and discovering the family of man". This paper identifies the participants in the first phase of the project and those lined up for the second phase and classifies them as industrial or developing nations. It evaluates, in particular, the involvement and participation of the third world countries emphasizing the need for a different approach to attract them to join and to display their past history and civilization. They can still be economically poor, but their customs, traditions and culture could not be ignored in the context of a world community.

SATURDAY 10:45 am Carlton Student Union, Room 204/205
BUSINESS MEETING: Social Sciences Section
SANDRA SULLIVAN GUEST, University of Central Florida, presiding

URBAN AND REGIONAL PLANNING

FRIDAY 8:00 am Sage Hall, Room 205
E. LYNN MOSURA, presiding

8:00 am URP-182 The State Role in the Comprehensive Planning Process. DALE R. EACKER AND DAVID M. DAVIS, Department of Veteran and Community Affairs, Bureau of Local Government Assistance, 2571 Executive Center Circle, East, Tallahassee, FL 32301. Florida law requires every city and county, and certain special districts, to prepare, adopt and implement comprehensive plans. The state law also requires development of plans at the state and regional levels and establishes a review process to help insure these plans are consistent. Taken together, these statutes create a hierarchical planning process that is designed to insure the coordination of planning and development activities of units of local government with the planning activities of regional agencies and state government.

8:15 am URP-183 The Local Government Comprehensive Planning Act: A six year review. ROBERT F. KESSLER AND DAVID M. DAVIS, Department of Veteran and Community Affairs, Bureau of Local Government Assistance, 2571 Executive Center Circle, East, Tallahassee, FL 32301. The completion of the first phase of this Local Government Comprehensive Planning Act Program on July 1, 1981, provides an excellent opportunity to reflect and report on what has happened during the first six years of this landmark legislation, including some of the more significant activities resulting from the passage of this law from the state perspective.

8:30 am URP-184 Planning, People and Ecological Principals. JEFFREY L. LINCER AND DENNIS WILKISON, Sarasota County, P.O. Box 8, Sarasota, FL 33578 and JULIE MORRIS AND JONATHAN MILLER. Environmental Studies Program, New College, 5700 N. Tamiami Trail, Sarasota, FL 33580. Included in the intent of the Local Governmental Comprehensive Planning Act of 1975 was to "...encourage the most appropriate use of land, water, and resources..." (Section 163.3161, F.S.). It required consideration of, and provided a mechanism for, environmental awareness and assessment in conjunction with the planning process. In response to this state-mandated opportunity, a habitat map was generated for all of Sarasota County (Fla.). Subsequent to identifying the extent and distribution of native habitats, their most important values and functions were identified and ecologically-based management guidelines were prepared. The Environmental Element of Sarasota County's adopted Comprehensive Plan, which embraces the above management guidelines, is now an integral part of a legal basis for making the all-important and far reaching local land use decisions.

8:45 am URP-185 The Potential for Water-related Growth Management in Florida through the TDR Concept. HERBERT H. W. HEESCH, Withlacoochee Regional Planning Council, 1241 S. W. 10th Street, Ocala 32674-2798. The purpose of this article is to present a workable methodology whereby the inter-basin transfer of water may be accomplished with minimal adverse impacts upon either the affected political jurisdiction or upon the environment. The use of TDR as a control device for inter-basin transfers is proposed, by linking available water to development potential. An example of how the proposal would work is provided, with a discussion of the need for a water budget. As a part of the summary and conclusions, the article proposes that any inter-basin transport should involve a proportional transfer of development rights.

9:00 am URP-186 Flood Management. C. E. COMER, Southwest Florida Water Management District, 5060 U.S. Hwy. 41 S, Brooksville, 33512. Since 1970, the Southwest Florida Water Management District has been conducting a flood plain analysis and aerial topographic mapping program. Heretofore, little was known about the statistical frequency of flood elevations along the major rivers and lakes in this region of the state. Further, no detailed base maps with close interval contours existed on which these elevations could be delineated with any degree of accuracy. The program has provided communities and counties within District boundaries with the technical information necessary for sound flood management. As a companion to the technical program, a model flood management ordinance is being developed for adoption by local governments. The ordinance identifies types of flood hazards, flood control measures, sound development practices, administrative and enforcement procedures. Its purpose is to assist local governments in the management of flood-prone lands, aid in water conservation, meet the standards of the Federal Insurance Program and, most of all, reduce the tragedies and costs associated with floods.

9:15 am URP-187 The Role of Local Governments in Agricultural Preservation: The Hernando County Experience. E. LYNN MOSURA, P.O. Box 112, McIntosh, FL 32664, James G. King II, P.O. Box 1532, Brooksville, FL 33512 and Lawrence Jennings, Hernando County Planning and Zoning, 134 E. Jefferson Street, Brooksville, FL 33512. As part of the implementation of the Hernando County's Comprehensive Plan adopted pursuant to the LGCPA of 1975, the county's planning staff set out to determine acceptable means of protecting valuable agricultural land. The presentation will focus on the inventory and assessment of local agricultural resources, the involvement of the agricultural community in the planning process and the recommendations to utilize TDR as a major strategy in the preservation program.

9:30 am URP-188 McKay Bay Refuse-to-Energy Project: Recent History of Resource Recovery in Hillsborough County, Florida. JOSEPH D. MURDOCH, McKay Bay Refuse-to-Energy Project, City Hall Plaza, 5N, Tampa, Florida 33602. The disposal of municipal solid waste is a major concern for many Florida governments. In 1977, Hillsborough County's governments initiated an investigation of possible long-term solutions to the solid waste disposal problem. This initial investigation determined that resource recovery was a feasible alternative for solid waste disposal, and the local governments initiated investigation and planning efforts for a refuse to energy system. Resource recovery is the systematic recovery and use of recyclable materials and energy from discarded waste. Planning efforts have culminated in the implementation of the conversion of the closed Tampa Municipal Incinerator to a 1000 ton per day refuse-to-energy facility. The facility, which is scheduled for a 1985 completion, will provide for the disposal of the City of Tampa's garbage and the generation of approximately 20 MW of electricity.

FRIDAY 9:45 am Sage Hall, Room 205
BUSINESS MEETING: Urban and Regional Planning Section
E. LYNN MOSURA, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

MEDICAL SCIENCES

FRIDAY 11:00 am Carlton Student Union, Private Dining Room
MICHAEL J. SWEENEY, University of Central Florida, presiding

11:00 am MED-189 **Evaluation of the Effectiveness of Anti-inflammatory Drugs using 45-53 μm Divinyl Copolymer Beads in the Mouse Lung. MAI-ANH PHAM, MARY LAURIE PERTAIN, SYLVIA E. COLEMAN AND C. IAN HOOD. VA Medical Center and University of Florida, Gainesville, Fl 32602. The effects of six anti-inflammatory agents on the foreign body response to 45-53 μm diameter divinyl copolymer plastic beads injected into the tail veins of mice was studied. The injected beads embolize to the lung and initiate a granulomatous inflammation which reaches a maximum size in 48 hours. This reaction was used as a control for testing the activity of six different anti-inflammatory drugs in reducing the granulomatous inflammation. Drugs tested were hydrocortisone acetate, polyanetholsulfonate, bacterial levan, ellagic acid, azathioprine, and acetylsalicylic acid. Areas of the granulomas were measured with a Numonics calculator from tracings of paraffin sectioned lung tissue. All the drugs tested reduced the mean area of the granulomas by at least 60%. The most effective of the drugs studied were azathioprine, bacterial levan and hydrocorticone acetate which reduced the areas of the granulomas by as much as 92%.**

11:15 am MED-190 Apotryptophanase Activity in *Escherichia coli B* (WG 15) Starved for Pyridoxal. ROSEANN S. WHITE, University of Central Florida, Orlando, Fl. 32816. Optimal conditions previously determined for induction of apotryptophanase in the WG 15 pyridoxine auxotroph of *Escherichia coli B* were used to study the effects of coenzyme starvation on the synthesis of apoenzyme. The auxotroph induced maximally for apotryptophanase but starved for pyridoxal had an approximately 10 fold lower specific activity than the auxotroph induced for apotryptophanase in the presence of 10^{-7} *M* pyridoxal. Addition of 3'5'adenosine-5'-phosphate to the growth medium had no effect on apotryptophanase activity and therefor indicated that the differences in activity were not due to a differential release of catabolite repression by glucose. Addition of coenzyme to extracts of the auxotroph starved for pyridoxal and induced for apotryptophanase produced no stimulation of apotryptophanase activity. Additional studies will determine whether the decreased apoenzyme synthesis upon starvation for pyridoxal is specific for vitamin B_6 requiring apoenzymes.

11:30 am MED-191 The *in vitro* Response of Murine Macrophages to Infection with *Histoplasma capsulatum*. Kirk L. Searls and Deborah A. Nickerson, Department of Biology, University of South Florida, Tampa, FL 33620. *Histoplasma capsulatum*, a dimorphic fungi, can cause a severe disseminated disease, which leads to depression of host immune function. Experimental evidence from both the clinical situation and a murine model of infection have implicated the macrophage/monocyte series in the generation of this immune depression. In the present study, we have explored the possibility that *H. capsulatum* infected macrophages might secrete a soluble factor(s) with immunosuppressive properties. To accomplish this mouse peritoneal macrophages were incubated with varying numbers (10^2 to 10^6) live *H. capsulatum* yeast phase cells. Controls consisted of macrophages incubated with equivalent numbers of heat-killed *H. capsulatum* or latex beads. Our results indicate that supernatants from macrophages paratisized with live *H. capsulatum* contain a factor or factor(s) with the capacity to depress *in vitro* antibody formation to sheep red blood cells by normal spleen cells.

FRIDAY 11:45 am Carlton Student Union, Private Dining Room
BUSINESS MEETING: Medical Sciences Section
MICHAEL J. SWEENEY, University of Central Florida, presiding

FRIDAY 1:30 pm Elizabeth Hall Auditorium
PLENARY SESSION I: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

FRIDAY 6:30 pm Carlton Student Union, Stetson Room
BANQUET and PLENARY SESSION II: The Florida Academy of Sciences
DANIEL B. WARD, University of Florida, presiding

NOTES

LIST OF PARTICIPANTS

ABBREVIATIONS: Bus Mtg, Business Meeting; p, presiding; PLE, Plenary Session; see inside front cover for section abbreviations.

A

ALDRICH H C	BIO-84
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ANDERSON J	ENG-118
ANDERSON K	BIO-111
ASPER E	BIO-100
ASPY D	ENV-127
ATTARDI V J	BIO-105
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NOTES

THE FLORIDA ACADEMY OF SCIENCES

THE FLORIDA ACADEMY OF SCIENCES was established in 1936 and serves as its founders intended by sponsoring an annual meeting, publishing a journal of interest to scientists in Florida and carrying forward programs such as the Junior Academy to encourage youth in science. The Academy is incorporated as a nonprofit scientific and educational organization in Florida and is similarly recognized by the by the United State Internal Revenue Service under the provisions of Section 501(c)(3) of the IRS Code. Despite the fact that the Academy serves as an important means of communication of scientific research data developed by state agencies as well as from the State University System, it is unlike most State academies in that it receives no State assistance. Thus, the Academy exists independently from governmental support by means of membership dues, sale of its publications, occasional gifts or grants and modest registration fees at meetings.

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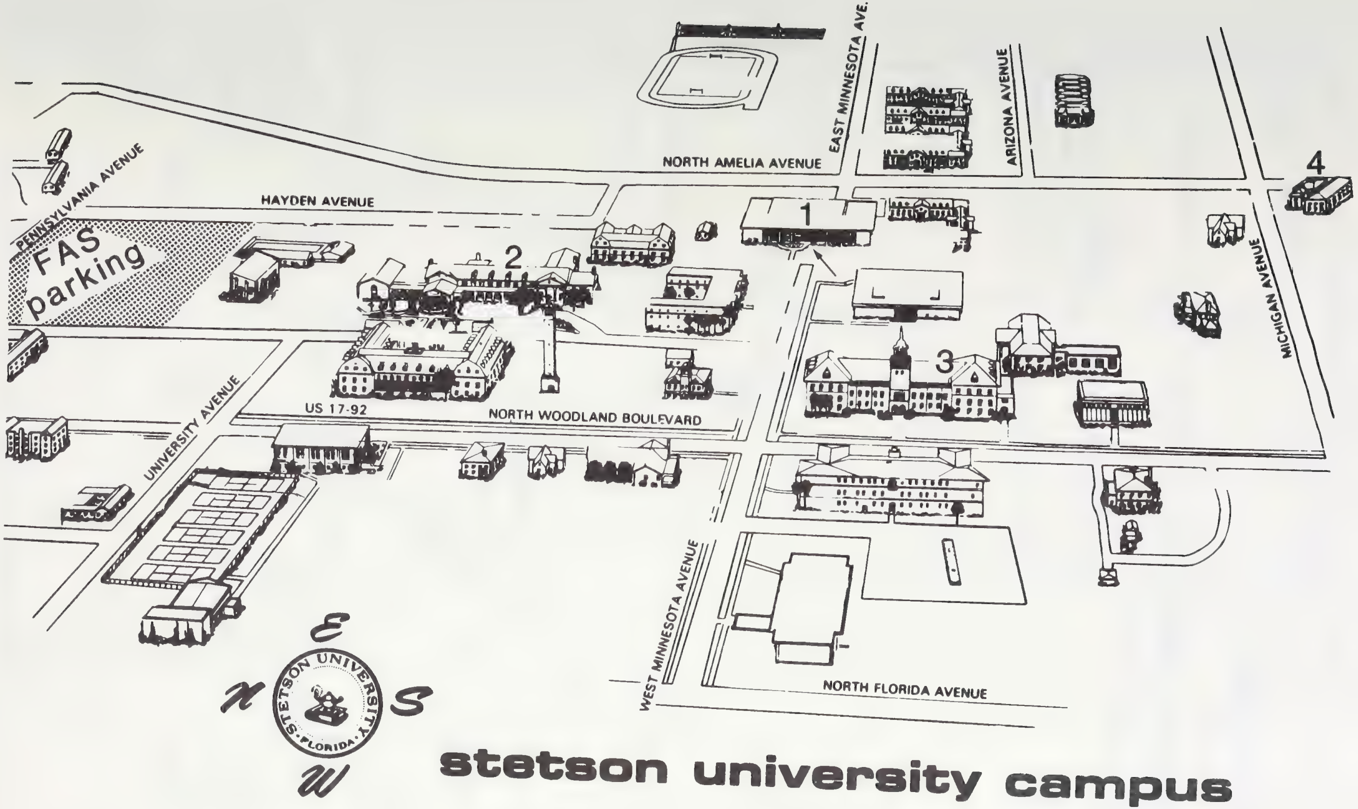
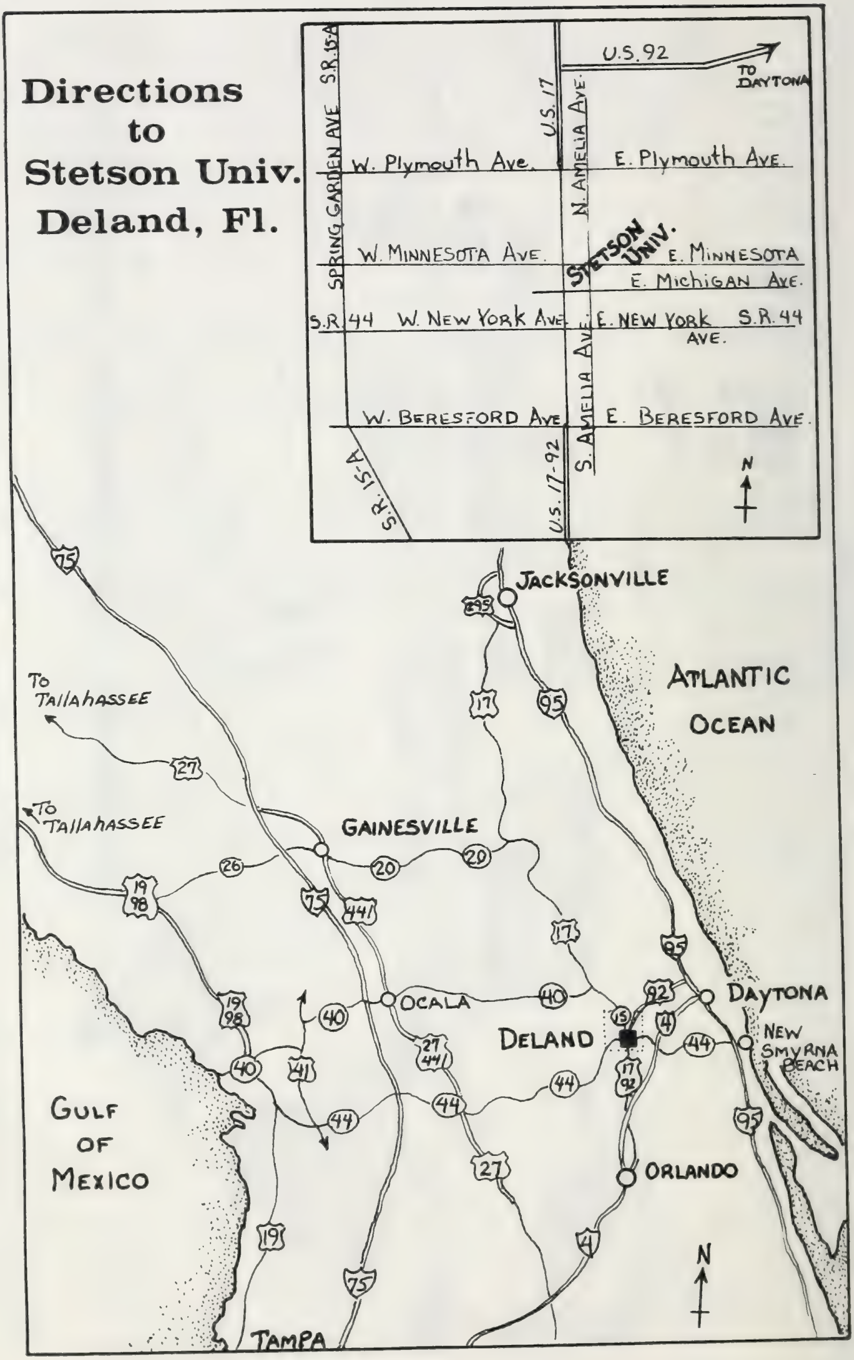


stetson university campus

1 Sage Hall (arrow, FAS registration)   2 Carlton Student Union   3 Elizabeth Hall   4 Gillespie Museum of Minerals

Directions to Stetson Univ. Deland, Fl.



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